SCIENCE

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Features

Departments

The purpose of the Science Information Systems Newsletter *is to inform the space science and applications research community about information systems development and to promote coordination and collaboration by providing a forum for communication. This publication focuses on programs sponsored by Information Systems in support of NASA's Office of Space Science. Articles of interest for other programs and agencies are presented as well.*

Lead Feature

Challenges in Space and Earth Science

Since the earliest days of computing, the scientific questions being posed have generally exceeded the capabilities of the systems used to generate answers. However, over time the combination of advances in hardware technology, software tools, and operating systems, and mathematical libraries and algorithms have contributed to narrowing the gap between question-and-answer and simulation-and-reality. This has resulted in supercomputing contributing to major breakthroughs in understanding our universe.

A workshop on the "Computational Challenges in Space and Earth Sciences" was held at the Jet Propulsion Laboratory (JPL) in Pasadena, California, on June 12-14, 1996. It was convened to provide an opportunity for scientists from universities, NASA, other government organizations, and research facilities to share information and perspectives on the opportunities and obstacles in using high performance computing to advance their research. The intent of the workshop was to provide a science-driven assessment and characterization of computing requirements, and lay the foundation for an integrated scientific computing strategy that is explicitly connected to NASA's scientific research strategic roadmaps. The organizing committee members were:

- Joe Bredekamp—Senior Science Program Executive, Information Systems, NASA Office of Space Science
- George Lake—University of Washington, Professor of Astronomy and Physics
- Tom Prince—California Institute of Technology, Professor of Physics
- Chuck Goodrich—University of Maryland, Associate Research Scientist
- Paul Messina—California Institute of Technology - Director of the Center for Advanced Computational Research, and JPL - Manager of High Performance Computing and Communications
- Carl Kukkonen—JPL, Director of the Microelectronics Laboratory, and Supercomputing Project
- Larry Eversole—JPL, Deputy Director for the Supercomputing Project
- John Champine—JPL, Program Manager for Supercomputing and Space Science

One of the distinguishing characteristics of this workshop was the desire to create a science-driven (as opposed to a technology-driven) view of the role of high performance computing within NASA. Following a small group of plenary talks that provided the background and set the stage, the majority of time was spent in breakout groups. These breakout groups were organized to work with a science-driven view on the first day and with a computationally defined perspective on the second day. The groups were organized as:

- solar physics and space weather
- galaxies, universe, and planetary systems
- galactic astronomy: stellar evolution, interstellar medium, nebula, pulsars
- climate, atmosphere, and oceans
- simulation theory and distributed computing
- data searching, mining and fusion, and real time and pipelined data analysis

Participation in this workshop was by invitation. Those invited are known within the community as leaders, both in science and in the use of high performance computing technology.

Highlights of plenary session

JPL's Director, Ed Stone, and Carl Kukkonen welcomed the participants. The workshop was then kicked off with Joe Bredekamp's "NASA Scientific Computing

Perspective", a report on NASA's current process of establishing strategic roadmaps organized around key interdisciplinary science themes, which are:

- exploration of the solar system
- astronomical search for origins and planetary systems
- the sun/Earth connection
- structure and evolution of the universe
- origin and distribution of life in the universe

Bredekamp explained that correlated roadmaps are also being developed for enabling technologies and capabilities for achieving these science objectives.

Various members of the community then presented summaries of success in creating very high impact science from computation, as well as fundamental changes in the way that computing has been done as a result. Topics and presenters were:

- " Problems in Computational Cosmology"—George Lake, Professor of Astronomy and Physics, University of Washington
- " Data Intensive Computational Problems in Space Astronomy"—Tom Prince, Professor of Physics, California Institute of Technology
- "Computing Perspectives for Space Physics"—John Lyon, Research Professor, Dartmouth College
- " Chemical Tracer Simulations for Climate and Other Applications"—Rich Turco, Professor of Atmospheric Sciences, University of California at Los Angeles
- "Four Dimensional Data Assimilation for the Atmosphere"—Peter Lyster, the Joint Center of Earth System Science at University of Maryland-College Park, and the Data Assimilation Office at Goddard Space Flight Center
- "Directions in Computational Technology"—Paul Messina, Director of the Center for Advanced Computing Research, California Institute of Technology, and Manager of HPCC at JPL
- "Computational Challenges: a National Science Foundation (NSF) View"—Robert Voight, HPCC Coordinator of NSF

Findings

The ability to effectively process data has become as important as the desire for increased performance in the traditional computer areas of processor speed, memory capacity, I/O performance, and networking latency and bandwidth. Currently more resources are going into producing data than into utilizing it. For example, many astronomical data sets are, or will soon be 10-20 TB of raw data, and 1 TB of processed information. In five years, these data sets will grow to 100+ TB. Information extracted by application of new computing technology to existing data sets is often a very powerful and cost-effective source of new science (e.g., IRAS (statistics, re-mapping), Magellan, ROSAT). Because utilization of a data set in multimission mode typically takes place over ~1 decade, there is a need to retain access to low-level data for an extended period of time, to allow for future re-analysis.

It was also determined that simulations should be included in the archival programs (retain the application along with the data), but this poses the problem of how to cross-correlate large data sets plus their simulations. Currently, state-of-the-art in software technology (object orientation) allows for the tight binding of data with an application. However, historically most data sets have been collected independent of the applications used to process them. In order to achieve the objective of tight binding of data, a meta-indexing concept that abstracts the data and application, needs to be developed and standardized, to allow multiple use and re-use.

Classically, experimental observation and data collection has produced data sets that are focused on the results of specific instrumentation and project or mission objectives. Because many of the areas of research and application development require the need to access, analyze, and fuse multiple data sets in multiple formats stored in multiple locations, a major challenge in the management and accessibility of these data sets is posed. More computer-assisted interactive analysis for data queries, fusion, and mining are needed.

In simulation and modeling, the community determined that while the predominant workload for the foreseeable future will be in traditional modeling and simulation, there are also new opportunities for applying simulation to important space science objectives, particularly those related to instrument design and mission planning. Simulation can be used to

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Readers are invited to contribute articles or information regarding published works, awards, announcements (research, opportunity, or CANs), or calendar events for publication. All submittals, changes of address, or questions or comments on content should be sent to the Editor, Sandi Beck, Telos Information Systems, 320 N. Halstead #260, Pasadena, CA, 91101; 818-306-6691; sandi.beck@jpl.nasa.gov

All articles and photographs without bylines were written or taken by the Editor, Sandi Beck. Editorial assistance is provided by Pat Kaspar, Ames Research Center, and Judy Laue, Goddard Space Flight Center. Print layout and Web page administration by Sandi Beck.

both help define requirements for new missions and plan experiments and as an integral part of those experiments and missions. For example, front-end detectors (on-board processing) for interferometer and other missions can be simulated to provide behavioral models of the real-mission detectors. Also, engineering design can be enhanced through simulation.

On policy issues, the determination was that a number of the challenges facing investigators in space and Earth science are not of a technology origin; rather, they stem from program and policy issues created by the various funding and resource provider institutions and organizations. Supercomputers should be used as supercomputers, not as free cycles to researchers, regardless of the requirements of their applications. Also, high-end supercomputers should be reserved for the most demanding problems, especially those with wall-clock or memory constraints, such as eddy-resolving ocean models, data assimilation (especially Earth Observing System data), charged coupled atmospheric/chemistry models, and non-hydrostatic atmospheric/oceanic models.

The ability to effectively process data has become as important as the desire for increased performance in the traditional computer areas of processor speed, memory capacity, I/O performance, and networking latency and bandwidth.

Addressing obstacles

While addressing the issues of how to answer, through use of high performance computing, the fundamental questions about Earth and the universe, a number of obstacles were identified. For instance, system management and time allocation sometimes work to a disadvantage for serious users of supercomputing. Too many small jobs are sometimes run at the expense of major, long running simulations or data analysis. Work should be partitioned to run on the most cost effective platform when possible.

Changing computer technologies that affect software development promote additional obstacles. The lack of uniform semantics for portability (currently there are several approaches to thread libraries) and standards are good examples. With the diversity of architectures, researchers cannot create and maintain multiple versions of an application to fit on all prevalent system architectures. Also, massively parallel processors (MPPs) (>16 PEs) are still immature, both from a stability standpoint and from a lack of functionally rich software, as on parallel vector machines or workstations. Immature software is a key drawback for using MPPs and clusters of workstations for large problems. The mismatch between operating system design and the architecture and usage model of MPP/symmetric multiprocessor (SMP) systems has to be addressed by vendors.

Additional obstacles defined are in the scope of networks and data transportation. The shortcomings of currently available long-haul networks are a major deterrent to the use of remote supercomputer facilities; sharply increased capacity is required. Data transportation, on-line and near-line storage, and archiving for big files (>100 GB) is a serious problem. Facilities and speeds required to process large data sets are still very embryonic.

Identifying needs

Conversely, the community identified several needs. For example, it is important to have a balance in all areas of computing to ensure that results are delivered in the shortest time frame; fast CPU's are of little use if it takes a disproportionate amount of time to transfer files to/from the system. Computing effectiveness should be measured in terms of time-to-solution, not only in terms of gigaflops and terabytes. Other necessities are: improved archiving facilities for both local and remote sites; distributed archives for simulations, as well as for observational data; better tools for the visualization of multi-GB outputs from models; very large data bases in a time-dependent manner; parallel I/O standards and facilities, pre-processing of measurements to extract information for data assimilation; robust parallelizing compilers and parallel tools (HPD, MPI, etc.) that have uniform standards of interface and function; and improved and standardized latency-hiding facilities for network communication.

Proposals and recommendations

Workshop participants had been challenged to think about and come prepared to discuss science opportunities that can be supported through use of high performance computing. They were asked to describe those opportunities where the quality of the science was directly tied to the quality of the supercomputing resources (performance, reliability, user environment, etc.). Three proposals were discussed during the workshop: the 'Digital Sky', determining the morphology-density relationship of components in the universe, and views and animation of space data.

Several recommendations came out of the workshop. For example, interoperability is a must across administrative boundaries and can only be achieved through standardized software interfaces and environments. Another recommendation is that because management of resources (i.e., hierarchical data format, common data format, etc.) must be the norm across all platforms, better software tools are still needed to make the MPPs easier to use. Also, because the Internet is losing bandwidth to support data intensive activities (such as remote visualization) as more and more users access the network daily, there should be reliable high-speed networking among all research centers. Perhaps there should be a reserved network for only that purpose.

Other recommendations include use of local site SMP and high-end workstations to reduce the pressure of the small-to-medium-sized jobs on high-end supercomputers and building human infrastructure to take on projects involving computational technology such as the advancement of software, methods and analysis, algorithms, tools, etc. Lastly, employing improved cross-discipline approaches to problem solving can yield enormous dividends, and should be encouraged whenever possible.

Conclusion

The objectives of the workshop were to show the past impact of advanced computing in space and Earth science research, to show the value of continued commitments to high performance computing resource, to recommend changes in computing at NASA (resources, structure, management, other), and to optimize the impact of advanced computing on future science research.

The workshop provided major practitioners in space and Earth simulation and modeling an opportunity to assess and characterize science computing requirements. It also provided an opportunity to hear from the community, to gain an overall sense of how NASA is doing, and to identify any shortcoming in the computing environment—captured through an organized voice, as opposed to anecdotes. The workshop was valuable in establishing linkages of leading science challenges with computational technology, along with their priorities, and in establishing a basis on which to evaluate investments both in current capacity and advanced technology. Additionally, it provided an opportunity to send collective messages to NASA on the state of computing for science, and recommendations for improvement.

Excerpted from the Report on the Computational Challenges in Space and Earth Science Workshop *compiled by John Champine and Larry Eversole of the Supercomputing Project at JPL.*

Editor's Corner—

Final Hard Copy

The newsletter has been in existence for over a decade now, covering a broad range of information trends. I was privileged to assume editorship two years ago when the former, very talented editor moved on to other enterprises. As editor I implemented the OUTREACH and Spinoff departments to report NASA's contributions to education and the many adaptations of space science technology. In mid 1995 we began to publish electronically on the World Wide Web (WWW), in addition to print media. In the new year we will be implementing a further change—the transistion to electronic-only publishing.

Although most agree that electronic publishing won't ever completely replace hardcopy output, it *is* becoming more and more mainstream. Electronic media offers new, exciting capabilities almost daily. We are now living and working in the "Information Age" where technology has changed the ways in which we communicate and the ways in which information is used and presented. These new technologies, and how they allow us to manage and master information, are enticing. More to the point, ever increasing pre-press, print, and distribution costs are strong impetus to consider an electronic-media-only newsletter.

On the up side, there are numerous benefits to minimizing the number of hardcopies and transitioning solely to electronic publishing. Besides cost savings, there are time savings in production, rapid delivery to subscribers, more current information, and the incorporation of those new technologies. Also, there is the environmentally sound benefit of saving trees.

As this transition became a major consideration, a survey of subscribers was made (by email). The survey encompassed the range of interests and uses of the newsletter by NASA employees and domestic and foreign educators, scientists, and engineers, many of whom also regularly contribute articles. While the survey response was largely favorable, there is a small fraction of subscribers who make a good case for the portability of print and the current limitations of monitors for reading purposes. Those responding from foreign countries (and a very small number within the US) expressed concern over low bandwidth, slow modems, and inadequate internal networks. These are important concerns and were taken into account in planning for future information flow.

After investigating the new technologies, surveying a cross-section of the readership, and examining the budget against the costs of current business methods, the future objectives for the newsletter were defined, and a proposed new direction was developed. First and foremost, the newsletter will continue to provide a valuable, high quality forum for information and communication. Secondly, the intent is to reach the widest audience possible through the use of current and new technologies in the ever expanding world of electronic publishing and the WWW.

Therefore, dear reader, this issue is the final hardcopy issue to the general readership. Beginning February, 1997, the newsletter will be published on the WWW as smaller, more current issues, available every two months. Libraries and archives will continue to receive a print version, albeit possibly in a new format. A mirror site will be set up in Europe to accommodate ease of on-line access for the foreign subscribers. Also in 1997, the existing website will be improved to accommodate various browsers and user platforms. Many of the features requested by those surveyed, plus other features determined in-house (e.g. a search engine on keywords and authors) will eventually be incorporated.

Harnessing the power of the Internet will allow contributors to augment the narrative of a project or task with other media, such as video, sound, animation, and virtual reality, as well as with color graphics (versus print black & white only). The result is a blending of technical communication technologies, while retaining content quality.

Although we hope to have the new electronic-only version (with all the bells and whistles) ready as quickly as possible to meet not only the needs of our readership, but their expectations, transition is not without obstacles or angst. So, please bear with us. However, feel free to email your comments or suggestions to either Sue LaVoie or me at, respectively:

sue_lavoie@iplmail.jpl.nasa.gov
sandi.beck@jpl.nasa.gov

While we are transitioning to our new website, please continue to access the homepage currently at:

http://techinfo.jpl.nasa.gov/jpltrs/sisn/sisn.html

For your records, the new uniform resource locator (URL) will be:

http://www-sisn.jpl.nasa.gov

The website will most likely be transitioned to the new server by late January. Once the website is transitioned, a pointer to the new URL will be provided on the current homepage.

The new website will offer a subscription service, to which you will be directed to provide your email address. You will then be automatically placed in the distribution database and notified of each new or updated issue as it comes on-line. Once the transition is completed, we will begin work on revising the format, adding new features, and implementing the "bells and whistles."

Statistics will be collected in the ensuing months and reported to the readership prior to the next fiscal year, at which time the transition to electronic-only publishing will be re-evaluated.

Thank you for your continued interest, your constructive criticism, and your compliments over the past two years. We hope to continue bringing interesting and useful information to all of you.

Calendar

JANUARY

26-30 Space Technology and Applications International Forum, Albuquerque, NM; NASA; Professor Mohamed S. El-Genk; 505-277-5442; FAX: 505-277-2814; mgenk@unm.edu

FEBRUARY

9-14 Electronic Imaging: Science and Technology; IS&T, San Jose, CA; IS&T and SPIE; 703-642-9090 x10

17 Integrating Spatial Information Technologies for Tomorrow, Vancouver, Canada; GIS World; 970-223-4848; FAX: 970-223-5700

13-18 AAAS Annual Meeting and Science innovation Exposition, Seattle, WA; Dee Velencia; 202-326-6417; FAX: 202-842-1065

MARCH

25 ACM97: The Next Fifty Years, San Jose, CA; ACM; acm97expo@acm.org

17-19 Fourth International Conference on Remote Sensing for Marine & Coastal Environments: Technology and Applications, Orlando, FL; ERIM; raeder@erim.org

21-27 AM/FM International Annual Conference, San Antonio, Texas; AM/FM International; Paula Delie; 303-337-0513

25-27 Data Compression conference '97, Snowbird, UT; IEEE Computer Society TCCC; dcc@cs.brandeis.edu

APRIL

1-5 Association of American Geographers Annual Meeting, Fort Worth, Texas; AAG; 202-234-1450; gaia@aag.org

Feature

Reducing Risks for NASA's Data Archives

Jeanne Behnke and Ben Kobler, Earth Science Data and Information Systems Project, Goddard Space Flight Center

NASA has been collecting and saving science data since it was begun in 1958. Traditionally, data has been stored in analog form (e.g., on paper, tapes, microfiche, photos, etc.) and in digital format (e.g., on magnetic tape or disk, etc.). Digital recording of data has seen many changes over the past years, providing new ways to access and save data. The quantity of data has soared and projects like the Earth Observing System (EOS) must expect to archive many petabytes of data. Scientists will remember the past, when it would take many days to get data from a NASA archive, and contrast that with present systems that deliver data in seconds. Every mission at NASA that plans to support data acquisition, dissemination, and archive looks to new hardware and software mass storage systems to accomplish the task.

However, new technologies in mass storage systems are not without risks, often expensive risks. Consequently, the Earth Science Data and Information Systems (ESDIS) project has developed some approaches to mitigate the risks to developing the EOS and other NASA archives. The Data Archive and Distribution System (DADS) segment of ESDIS is focusing on three storage systems issues that represent significant risks to archive programs: insufficient standards to enable interoperability, insufficient reliability and performance, and unproven scalability.

A problem with current mass storage systems is that their hardware and software components are not easily interchangeable.

Standards

A problem with current mass storage systems is that their hardware and software components are not easily interchangeable. Software components, like the UniTree file storage management system, format the media in a storage device in their own, often proprietary, format. Archives can not easily replace their file storage management system with a different product because they are unable to read the media. Having NASA data in a vendor proprietary format inhibits long term archiving. Clearly there is a need to have vendors format data in a standard fashion.

ESDIS DADS is supporting work on developing standards for both file storage management systems and sequential storage media. Work has been funded to develop applications programming interfaces for the IEEE Mass Storage Reference Model v5. These standards will provide the foundation for interchanging many of the components of a mass storage system [1]. Another working group was organized to discuss file-level metadata and will develop interchange standards for data on sequential storage media (e.g., magnetic tape). The File Level Metadata for Portability of Sequential Storage Media (FMP) Working Group had its first meeting in Chicago in 1996. The activities of the FMP have been focused on working with vendors and users to document an interchange format for file-level metadata for data stored on sequential storage media. The initial proposal is for a three level structure (Figure 1), the structure being: data elements having to do with the tape; data elements having to do with files on the tape; and data elements having to do with the file system represented by the tapes. The FMP hopes to have made progress toward development of a standard [2] by late fall of 1996.

Reliability and performance

Another risk facing NASA archives is the difficulty in assessing the effectiveness of the mass storage system to be acquired. Often, these systems are new to the market and lack steady track records concerning reliability and performance. Mass storage systems are expensive items whether they are gigabytes or petabytes. It is difficult to determine how well a system will perform onsite based on the performance statistics provided by the vendor. Often each organization at NASA will need to carry out some type of test plan to validate the performance of the proposed system to be procured.

To mitigate this risk, ESDIS DADS is developing the Mass Storage Testing Laboratory (MSTL) to develop standard sets of benchmark tests for mass storage systems. This lab will be set up at Goddard Space Flight Center (GSFC) in the EOSDIS building. Mass storage benchmark software is being collected from associates and other agencies to be used to develop a peer-reviewed benchmark suite. The aim of the MSTL benchmark is to test vendor products and configurations with regard to file storage management software, archive media and recorders, and archive robotics. A report will be prepared about each configuration to be tested. The first set of tests were performed in December, 1996.

Another way of reducing such risks as insufficient reliability and performance information is to monitor technological developments. In particular, ESDIS DADS is focusing on development in optical tape, high performance magnetic tape, and holographic storage. In September 1996, DADS supported the Fifth NASA GSFC Mass Storage Systems and Technology Conference held at the University of Maryland. Since 1991, the conference has brought many NASA projects together with vendors of mass storage systems. Topics at the conference include mass storage systems and technologies architecture, standards, futures, database and file management, performance measurements, and vendor solutions. The three day conference, showcasing 45 selected papers, attracted over 300 participants. Conference proceedings can be found on the Mass Storage Conference home page at:

http://esdis.gsfc.nasa.gov/msst/msst.html

Scalability

Unproven scalability is another big risk to EOS, as well as other projects at NASA. The EOS data archive must be able to scale into the petabyte range through the year 2010. Not only must the mass storage system be able to store more data, it must also be able to access the data without taking substantial performance hits. To determine how a potential mass storage system might scale in size from terabytes to petabytes, ESDIS has supported the development of prototype software models. For example, one such prototype [3] models the performance of a robotic storage library under different stress conditions.

Conclusion

These three risk areas—lack of standards, insufficient reliability and performance, and unproven scalability—are not the only storage system problems facing NASA archives. Other data archive problems, begging for solutions, include a need for:

- high capacity storage systems that utilize cost-effective integration of off-the-shelf tape and optical technologies
- data organization schemes for optimum file access based on use access patterns
- scaleable file storage and management systems
- concepts for storage of information
- concepts for information stewardship
- system wide techniques for compression and decompression of files, objects, and databases
- system techniques to optimize data flow

ESDIS is seeking answers to these problems through Cooperative Agreement Notices (CAN-96-MTPE-01), a program to foster creative and innovative working prototype Earth science information partnerships in support of Earth system science.

For more information on any of these mass storage system programs, contact Ben Kobler or Jeanne Behnke at, respectively:

ben.kobler@gsfc.nasa.gov
jeanne.behnke@gsfc.nasa.gov

References

The following reference materials were used in the preparation of this article:

[1] M. Jones, J. Williams, and R. Wrenn, "A Proposed Application Programming Interface for a Physical Volume Repository," *Fifth NASA Goddard Conference on Mass Storage Systems and Technologies*, September 1996

[2] B. Kobler and J. Williams, "A Straw Man Proposal for a Standard Tape Format," *AIIM International Conference (IEEE)*, Chicago, IL. 1996

[3] T. Johnson, "Performance Measurements of Robotic Storage Libraries," *Fifth NASA Goddard Conference on Mass Storage Systems and Technologies*, September 1996

Planetary Data Systems—

Information Available on CD-ROM

The following data are available on CD-ROM and can be ordered by accessing the Planetary Data System (PDS) Catalog or by contacting the PDS Operator for assistance. Data are available to Office of Space Science scientists free of charge and to all others from the National Space Science Data Center for a nominal fee. The Catalog is available via the World Wide Web at:

http://pds.jpl.nasa.gov/

Select PDS Data Set Catalog listed under PDS Hot Topics!

- Clementine to the Moon Experiment Data Records - 88 volumes
- Earth Geologic Remote Sensing Field Experiment - 9 volumes
- Galileo to Jupiter Near Infrared Mapping Spectrometer EDR - 4 volumes
- Galileo to Jupiter Solid State Imaging REDR From Earth 2 Encounter - 15 volumes
- International Halley Watch Comet Halley Chronological Data - 25 volumes
- International Halley Watch Comets Crommelin and Giacobini-Zinner Data—1 volume
- Pre-Magellan Radar and Gravity Data - 1 volume
- Magellan to Venus Full Resolution Mosaic Image Data - 77 volumes
- Magellan to Venus Compressed-Once Mosaic Image Data - 45 volumes
- Magellan to Venus Compressed-Twice Mosaic Image Data - 20 volumes
- Magellan to Venus Compressed-Thrice Mosaic Image Data - 6 volumes
- Magellan to Venus Altimetry and Radiometry Composite Data - 19 volumes
- Magellan to Venus Global Altimetry and Radiometry Data - 2 volumes
- Magellan to Venus Line Of Sight Acceleration Profile Data Record - 1 volume
- Magellan to Venus Full-Resolution Radar Mosaics - 149 volumes
- Pioneer Venus Orbiter Magnetometer, Electric Field Detector, Ephemeris Data - 67 volumes
- Pioneer Venus Orbiter Supplementary Experiment Data Records - 4 volumes
- Pioneer Venus Orbiter Neutral Mass Spectrometer Data - 1 volume
- Viking Orbiter I to Mars Experimental Data Record Images - 32 volumes
- Viking Orbiter II to Mars Experimental Data Record Images - 14 volumes
- Viking Orbiter to Mars Digital Image Map - 14 volumes
- Voyager Images of Jupiter - 16 volumes
- Voyager Images of Neptune - 4 volumes
- Voyager Images of Saturn - 5 volumes
- Voyager Images of Uranus - 3 volumes
- Voyager Fields and Particles Data of Neptune—1 volume
- Voyager Fields and Particles Data of Uranus— 1 volume
- Welcome to the Planets Educational Resource - 1 volume

For further information contact the PDS Operator at:
pds_operator@jplpds.jpl.nasa.gov
818-306-6130

Spinoff

Tech2006 Showcases Technologies

Technology 2006, an annual event featuring the newest commercially promising technologies available for 1996, was held this year in Anaheim, California. This conference, sponsored by NASA, NASA Tech Briefs, and the Technology Utilization Foundation, provides the opportunity for companies to network, establish partnerships, grow their businesses, qualify for government funds, and obtain the latest information on technology transfer. This year's keynotes speakers were NASA Administrator, Daniel S. Goldin, and Netscape CEO, James Barksdale.

The conference was comprised of exhibits, poster presentations, technology sessions, and short courses. The technology sessions covered such topics as advanced manufacturing, agriculture, computers and communications, education, environmental technology, materials, medical and rehabilitative technology, physics, small business, aviation, and power and energy. Short courses offered covered patents and licensing, setting up intranets, and intellectual property.

NASA hosted a telemedicine workshop that presented sessions on telemedicine partnership opportunities; satellite communications for transmission of record, images, and live video; internet tools for medical education and telemedicine; advanced medical image compression, storage, and transmission technologies; and virtual reality tools for medical education and diagnosis.

This year's event was held concurrently, and co-located, with TeleCon, reportedly the world's largest trade show and conference devoted to videoconferencing. TeleCon offered exhibits and presentations on the many new applications of videoconferencing, such as distance learning and telemedicine.

NASA's wealth of technology is being re-used in the fields of medicine, industry, and education and by the military to develop products and processes that benefit many sectors of our society. Spinoff applications from NASA's research and development programs are our dividends on the national investment in aerospace.

Spinoff

Animating Urban Planning Tools

An animated view of the dramatic growth in urban sprawl over the Baltimore-Washington metropolitan region during the past 200 years was presented during the 1996 national convention of the American Society for Photogrammetry and Remote Sensing and the American Congress on Surveying and Mapping. The animation and its supporting database were produced by the Baltimore-Washington Regional Collaboratory, a cooperative effort between University of Maryland-Baltimore County (UMBC), the US Geological Survey (USGS), and NASA's Mission to Planet Earth enterprise.

Based for the first time on actual scientific data, the computer animation visually demonstrated how environmental, economic, and demographic forces can combine to generate a rapid change in the urban landscape. Developed using a combination of historical maps, census records, satellite-based imagery and geographic information systems, the animation tool and its supporting information was made available to local and regional urban planners via the Internet, to aid land and resource management policy development. The same process can be applied to generate similar products for other urban areas.

Excerpted from NASA press release N96-27 written by Allen Kenitzer, Goddard Space Flight Center, John Fritz, UMBC, and Ray Byrnes, USGS.

Mapping Beaches to Understand Effects of Coastal Storms

Powerful storms such as hurricanes can dramatically change the face of the coastline, eroding sand beaches in one area while increasing beach areas in another. Properly assessing the impacts of such storms is an enormous task. Now NASA and the National Oceanic and Atmospheric Administration (NOAA) are combining efforts to provide public officials with the tools they need to accurately assess coastal erosion. The goal of the joint project between the NASA Goddard Space Flight Center's Wallops Flight Facility and NOAA's Coastal Service Center (CSC), in South Carolina (SC), is to produce a highly detailed baseline map of the beaches between Cape Henlopen, Delaware, and Charleston, SC, an expanse of more than 560 miles, using airborne laser technology.

Federal, state, and local agencies have traditionally relied on photographs and spot surveys to assess the changing coastline. While these methods provide much needed data, they do not provide a precise enough account of topographical changes due to storms for the agencies to conduct fully effective shoreline development planning or beach replenishment programs, according to NASA Wallops Principal Investigator, Bill Krabill. Use of NASA instrumentation will provide cost effective and highly accurate mapping of beach erosion in particular, which is of great interest and concern to coastal communities.

The mapping is being performed with the NASA Airborne Terrain Mapper (ATM) flown on a NOAA Twin Otter aircraft. The ATM collects 3000 to 5000 spot elevations per second as the aircraft travels over the beach at approximately 150 feet per second. Using the ATM and a global positioning system (GPS) satellite receiver, researchers have been able to survey the beach elevations to an accuracy of four inches. NASA has surveyed the beaches from the low water line to the landward base of the sand dunes.

With the gathering of this baseline data, officials will for the first time have the capability to accurately quantify beach damage from a coastal storm," Krabill said.

NOAA's Coastal Remote Sensing Program Manager, John Brock, explained that due to the high human and economic costs associated with flooding and other coastal hazards, this type of information will help to support sustainable beach development and improved coastal management. Once the baseline study is completed and the use of this technology verified, the intent is to turn the technology over to the commercial sector to conduct future mapping for those assessing beach topography.

The east coast beach mapping field work is being conducted in two stages. During October 1996 a preliminary survey was made over a number of critical sections, including the coast between Cape Henlopen and Wallops Island; Virginia Beach, Virginia, to Oregon Inlet on the Outer Banks of North Carolina; Wrightsville, Top Sail, and Myrtle Beaches in North and South Carolina, recently hit by Hurricane Fran; as well as Folley and Isle of Palms Beaches north of Charleston. A complete survey is planned for the summer of 1997.

NASA is responsible for the operation of the ATM and the initial processing of the data. Mission planning and the follow-on processing of the survey information and its conversion into a format that can be directly used in geographic information systems will be jointly done by NASA Wallops and CSC. NOAA will take the lead in coordinating with different state and Federal agencies responsible for beach monitoring. The coordination with these agencies will include the organization of supporting beach ground surveys and the dissemination of the resulting airborne survey data base.

Excerpted from NASA press release 96-221 written by Keith Koehler, Wallops Flight Facility, and Jennet Robinson, NOAA Coastal Services Center.

Spinoff

Global Positioning Systems Aid Measurement and Study of Earthquakes

A network of 250 global positioning system (GPS) receivers is currently being installed in southern California. This network, called the Southern California Integrated GPS Network (SCIGN), continuously measures the constant yet physically imperceptible movements of earthquake faults. Recently, NASA Administrator, Daniel S. Goldin, dedicated a new site on the SCIGN at Rialto High School in Rialto, during a demonstration of the network's technology. Goldin was accompanied by US Representative George Brown, the ranking minority leader of the House Science Committee, and representatives from the National Science Foundation (NSF) and the US Geological Survey (USGS).

"This network is a tremendous example of how technology developed for space benefits life on Earth. This interagency project will give us detailed information never before available to track the invisible geologic strains and stresses that lie beneath the California landscape," Goldin said. "Such data should give us fresh insight into the forces that produce earthquakes, and could one day help reduce the loss of life and property from such disasters."

About SCIGN

SCIGN began in 1990 as a prototype project funded by NASA and is now a consortium of institutions with a common interest in using GPS for earthquake research and mitigation. The consortium is coordinated by the Southern California Earthquake Center (SCEC), an NSF technology center headquartered at the University of Southern California (USC). Lead institutions in the installation and operation of SCIGN are: Jet Propulsion Laboratory (JPL); the Institute of Geophysics and Planetary Physics-Scripps Institution of Oceanography at the University of California, San Diego; USGS; the University of California, Los Angeles; and USC.

Many of the receivers are being placed at schools so that students can be involved in the experiment. SCEC's "Global Science Classroom" at USC has formed a partnership with JPL, several school districts, and educators' groups to develop a science unit for use in schools. The unit, titled "The Elastic Planet," will give students access to the data being gathered by the network.

How it works

The SCIGN uses data transmitted from a constellation of 24 Earth-orbiting satellites that are jointly governed by the Departments of Defense and Transportation. The satellites are arranged so that several of them are "visible" from any point on the surface of the Earth at any time. Using a GPS receiver, you can determine a precise location by coordinating the signals from the satellites. Data collected by SCIGN will aid researchers in their study of earthquake faults in several ways. For instance, researchers have been able to determine that southern California has continued to move since the Northridge quake in 1994. According to Andrea Donnellan, a member of the SCIGN coordinating committee at JPL, the surface of the Earth is constantly moving and southern California is being squeezed in the process.

SCIGN will continuously measure movements of the Earth's crust with a precision of one millimeter per year and the data will show where strain is building up. Director of the USGS-NSF SCEC in Los Angeles, Tom Henyey, explained that this information will improve estimates of regional earthquake hazard in southern California and aid in prioritizing earthquake mitigation activities, including emergency preparedness and retrofit strategies. "Continuous GPS measurements also will allow for more rapid regional damage assessment following large earthquakes," he said.

. . . the surface of the Earth is constantly moving and southern California is being squeezed in the process.

GPS data are also important for identifying active buried faults that do not reach the ground surface and GPS measurements are useful in characterizing earthquake damage, according to members of the SCEC. Furthermore, placement of GPS receivers on such structures as dams, bridges, and buildings will help agencies monitor and detect probable damage to those structures.

For further information contact either:

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Don Kelly of USGS at 703-648-4466

Excerpted from NASA press release 96-218 written by Mary Hardin, JPL, Cheryl Dybas, NSF, and Don Kelly, USGS.

Spinoff

NASA Robot May Enhance Brain Surgery

A simple robot that can "learn" the physical characteristics of the brain soon may give surgeons finer control of surgical instruments during delicate brain operations. In a new procedure being developed at Ames Research Center (ARC) a robotic probe will "learn" the brain's characteristics by using neural net software, which is the same type of software technology that helps focus camcorders. The probe, equipped with a tiny pressure sensor, will enter the brain, gently locating the edges of tumors while preventing damage to critical arteries. Brain tumors typically have a different density than normal brain tissue. This difference allows neurosurgeons to find the tumor's edge through experience.

According to Robert Mah, principal investigator of the NeuroEngineering Group at ARC, the robot will potentially be able to 'feel' brain structures better than any human surgeon, making slow, very precise movements during an operation. Mah has been working with Russell Andrews of the Veterans Affairs Palo Alto Health Care System, who is also a clinical associate professor of neurosurgery at Stanford University, since 1994 to develop the smart robot. Andrews stated that NASA's Neurosurgical Computational Medicine Testbed is a unique and essential element in the goal to improve the safety, accuracy, and efficiency of neurosurgery.

During early tests scientists used tofu, a food made from soybeans that has a consistency very similar to brain tissue, to model tissue types.

The probes used on the robot are much smaller than standard probes, and should further reduce potential brain damage. During standard brain surgery, the surgeon uses a magnetic resonance image to guide placement of the probe in the brain. The physician samples the tumor by inserting a biopsy probe through an opening in the skull. According to Mah, a probe can be as large as 0.2 inches in diameter. As it enters the brain, there may be injury to brain tissue. If an artery is damaged as the doctor inserts the probe, the patient could bleed to death. In contrast, during the robotic neural net procedure, the speed and maximum pressure are controlled by a "smart" computer program that continues to learn as it gains more experience. If it hits an artery, the probe will stop before it penetrates. If the computer stops the probe, the surgeon can decide what to do next.

"Besides having robotic computer control, we have miniaturized everything. Instead of a probe that is almost 0.2 inches in diameter, all we need is a probe about one-third that size," Mah said. "That minimizes brain damage, too."

During early tests, scientists used tofu, a food made from soybeans that has a consistency very similar to brain tissue, to model tissue types. These tests were used to teach the neural net software what are normal brain tissues and arteries and what are not. The software learns to distinguish tumors from normal brain tissue by remembering the pressure signatures or profiles for each kind of tissue, and then making a model.

To view the robot, access:

http://ccf.arc.nasa.gov/dx

Excerpted from NASA press release 96-110 written by John Bluck, ARC, Mike Goodkind, Stanford University Medical Center News Bureau, and Irene Ohlendorf, Veterans Affairs Palo Alto Health Care System.

Feature

Roving Around on the Martian Surface

Tam Nguyen, Jet Propulsion Laboratory, and Jack Morrison, Telos Information Systems

The Mars Pathfinder MicroRover, a 10-kilogram robotic vehicle, will perform a number of engineering and science experiments on the Martian surface, paving the way for future Mars exploration. The rover, called Sojourner, will be operating in a harsh and largely unpredictable environment where direct human control is not feasible due to the limited-bandwidth communication link with long time delays. Therefore, it was designed to be autonomous; to reduce the frequency, cost, and bandwidth of operator communications and to improve reliability by rapid response to anomalies.

Sojourner is constrained by limited electrical and processing power—it cannot "walk and talk" (run drive motors and communicate over its radio modem) at the same time. Instead of a multi-tasking executive that would reduce performance without adding significant capability, the software is organized as a single control loop with interrupt handling for a few asynchronous reflex events (such as bumper contact) to which Sojourner must react quickly. This loop dispatches periodic functions such as thermal management, automatic vehicle health checks, and command upload requests as indicated by software timers; it also invokes command handlers as directed by the uploaded command sequence.

Navigation and hazard avoidance

Perhaps the most unusual component of the on-board software for a spacecraft is the waypoint navigation and autonomous hazard avoidance logic. Because Sojourner is normally directed along an operator-specified path based on 3D stereo images from the Pathfinder lander, it need not be a robust maze solver. However, it must watch for and deal with unexpected problems while moving.

The basic procedure for traversing to a waypoint is to drive forward in short segments, stopping for proximity scanning between each segment. In the absence of hazards, Sojourner arcs toward the goal position at one of a small number of fixed-radius turns. Inertial sensors and wheel encoders are used to dead-reckon the vehicle's location. While in motion, other sensors (such as inclination and motor currents) are sampled for hazard detection and telemetry. Several conditions are monitored:

- reaching an operator-specified timeout limit
- sensor-reading outside safe limits, from a able based on a risk-level parameter
- being too close to, and heading toward, the lander
- physical contact sensing

While Sojourner stops between segments, periodic low rate operations are performed, including a lander communication check heartbeat and the transmission of buffered telemetry data. Sojourner then uses its optical proximity scanning system to search for obstacles, such as tall rocks or dropoffs. The scanner consists of infrared lasers and charged coupled device imagers that are used to build a sparse, approximate map of terrain height in front of the rover. The map is searched for the following hazardous conditions:

- missing data inside the minimum required detection range, indicating a possible drop-off
- height difference between any two adjacent detections above a risk-level-dependent threshold, indicating a rock or hole
- height difference between lowest and highest detections above a higher threshold, indicating a steep slope

If proximity hazards are found in the map, Sojourner turns in place about its center to avoid them. It first turns in the direction of the smaller required avoidance turn, or toward the goal if there is no preference. On any subsequent turns at the same location, after re-scanning, it continues to turn in the same direction to avoid bouncing back and forth between two hazards. Non-proximity hazards, such as contact and sensor readings outside safety limits, result in aborting the traverse, *The basic procedure for traversing to a waypoint is to drive forward in short segments, stopping for proximity scanning between each segment.*

unless the operator has given Sojourner permission to deal with these autonomously. In that case, it backs up, turns, and tries again. Whenever it has turned away from a hazard, Sojourner moves straight ahead for a few segments before arcing back toward the original goal.

Normally, Sojourner tries to maintain enough distance from hazards to turn around if it should get into difficulty. The software provides an option to *squeeze* through narrower paths for a limited distance. If Sojourner encounters obstacles or fails to reach a clear area beyond this distance, it backs straight out and turns away from this narrow path, looking for another alternative.

Rock finding is a modified driving mode in which map data indicating a prominent rock triggers a behavior to center Sojourner between the edges of the rock by proximity sensing. If the destination waypoint is reached first, Sojourner performs a spiral search for a rock. Once a rock is found, the operator can then command the Rover to turn 180 degrees and direct its spectrometer onto the rock's surface.

Designing Sojourner

Sojourner's computer has 160K bytes of nonvolatile electrically eraseable programmable read-only memory (EEPROM) used to store the software, persistent state data, contingency command sequences (in the event of communication loss), and telemetry that cannot be immediately be sent to Earth via the Pathfinder lander (e.g., at night, when the lander modem may not be operating). The first 16K bytes of the memory space is populated by radiation-hard non-erasable PROMs, which contain the boot code first executed when Sojourner wakes up (it is solar powered and will normally shut itself off at night). This boot code computes and validates checksums on the EEPROM contents. If the EEPROM appears to be normal, control is passed to the normal EEPROM-resident software. Otherwise, a stripped-down rover control program, called "Rover Lite" takes over. Rover Lite can accomplish a subset of the mission objectives without depending on nonvolatile storage. It includes the full communication protocol, some diagnostic and memory patching capability, and low level device control, supporting approximately one-half the normal rover commands in some form.

Nearly all the global data is allocated in one of two structures: the *volatile state* area and the *persistent state* area. Volatile state data is initialized at each wakeup, and includes the latest sensor readings and navigation control states. The persistent state data is Sojourner's long-term memory. It is loaded from EEPROM at wakeup, and the EEPROM image is updated regularly as the state changes. This data includes mission phase, vehicle location, odometry, and long term time limits.

Each controllable device and each input sensor is associated with a device status value indicating the health of that device. The value is automatically adjusted if anomalous behavior (such as an out-of-range input) is reported from that device, typically during periodic health checks, and adjusted back if normal operation is observed. With several steps between "normal" and "failed" states, Sojourner can autonomously disregard suspicious sensor data, but recover from transient failures. At cold start, any such failures are re-checked once to see if all functions are again normal. If a sensor reaches a "failed" state, Sojourner avoids using that sensor to influence its behavior. If an actuator device reaches a "failed" state, Sojourner rejects operator commands that depend on that device. The device status values are reported with health check telemetry, and can be modified directly by operator command. Special values allow the operator to force a device into a "good" or "failed" state which the software will not alter autonomously.

Whenever a device is turned on, Sojourner monitors the electrical current drawn by that device, after a short delay to allow for transients. If this current exceeds a device-specific limit, Sojourner sets the device's status to an additional special "failed" state that prevents that device from being re-activated. It can even mark a device with this "keep off" state, if powering the device causes a system reset or trips the brownout-protection power monitor circuit. This logic reduces the possibility of depleting batteries or damaging electronics, should a device short-circuit. The "keep off" state can be cleared (or set) by operator command.

Numeric *constants* in Sojourner's software were implemented in three forms. Those that were certain to remain fixed were coded as compile-time constants (i.e., #define" preprocessor symbols or "enum" compiler constants). *Constants* that would probably remain fixed but could conceivably have to be altered (to deal with unexpected conditions) were coded as "const" values. This resulted in runtime constants stored in nonvolatile memory with the code. Because the values exist at a single location identified in the linker map, these could then be readily patched before or during the mission.

Run-time variables or control parameters are provided for a limited set of parameters that the operator might have to change during the course of the mission to alter vehicle behavior. A dedicated operator command allows these parameters, which are part of the persistent state data maintained in EEPROM, to be easily changed.

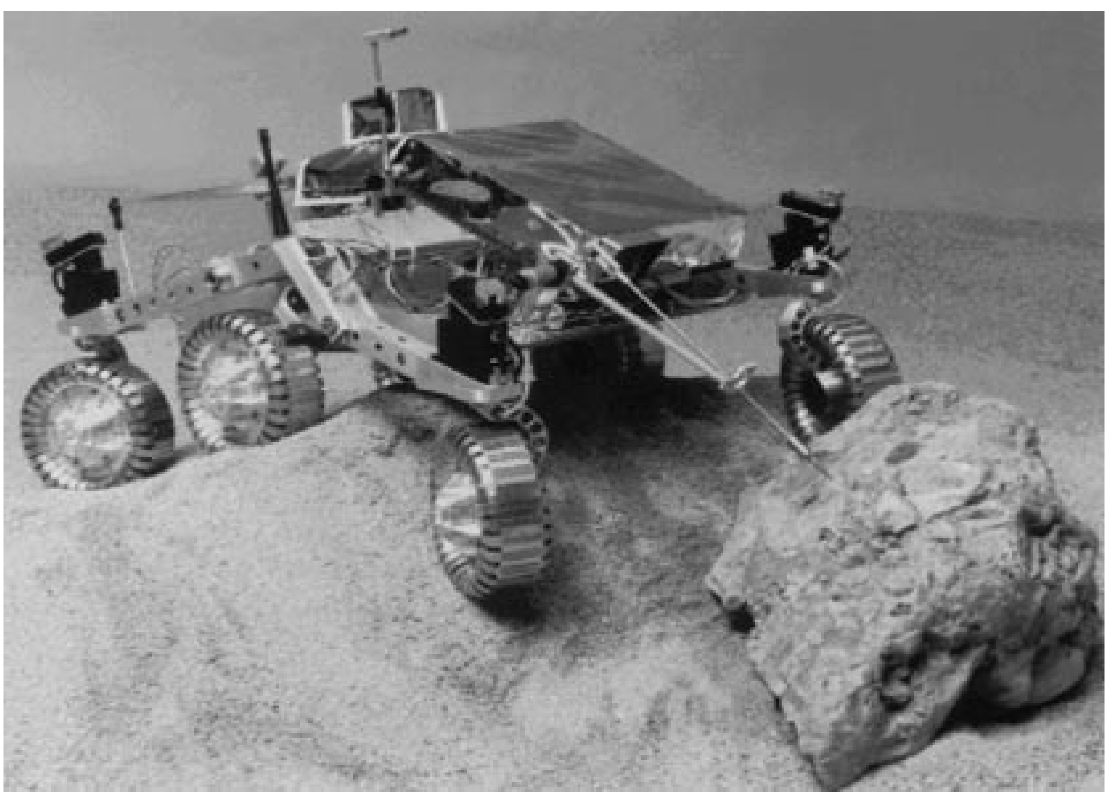
Two mechanisms handle error situations: an error reporting capability and error state flags. The reporting function is invoked whenever a new anomaly is detected. In addition to the error event reporting, eight error state flags track specific classes of error conditions such as device failure, invalid command, and command execution timeout. They are set when corresponding problems are detected and allow a limited form of conditional command execution; most comands are skipped if error states are active. All flags or a selected set can be cleared by operator command.

Collecting the data

Pathfinder, which launched in early December, 1996, is scheduled to arrive at Mars in July, 1997. Once on the Martian surface, Sojourner will collect and send back images and science data on soil and rock composition. Additionally, the team hopes to learn how well the vehicle itself functions as a tool for planetary exploration. With the detailed engineering data returned on performance of the solar power, thermal, mobility, communication, and navigation subsystems, the team should be able to build future rovers that search farther and unlock deeper secrets of other worlds.

For further information about the rover access either the Pathfinder mission World Wide Web homepage or the rover's homepage at, respectively:

http://mpfwww.jpl.nasa.gov/
http://mpfwww.jpl.nasa.gov/ROVER/sojourner.html



Model of Sojourner

Feature

Goddard's Massively Parallel Processor Joins Smithsonian Collection

Jarrett Cohen, Hughes STX, Earth and Space Data Computing Division, Goddard Space Flight Center

Goddard Space Flight Center's (GSFC) Massively Parallel Processor (MPP) has officially joined the collection at the Smithsonian Institution's National Air and Space Museum (NASM). A ceremony marking the occasion took place October 29, 1996, at the Sixth Symposium on the Frontiers of Massively Parallel Computation at Annapolis, Maryland.

The MPP introduced the US to the powerful concepts of massive parallelism. It was retired in March 1991 after eight years of service to the NASA scientific community. Appropriate to the ceremony's setting, the 28-member team MPP Working Group's findings made up the program of the first Frontiers Symposium, held in 1986.

"During its' time, the MPP was a unique testbed for parallel algorithm development and demonstration," said James Fischer, High Performance Computing and Communications manager. "Having a place in the Smithsonian collection testifies to the MPP's historical value as a predecessor to, and indeed a model for, today's fastest scalable parallel computers."

Early next century the MPP will be displayed at the NASM Extension at Dulles Airport, according to Paul Ceruzzi, curator of Computers and Avionics, Department of Space History, NASM. This exhibition also will include the Space Shuttle, Enterprise, and the SR71 Blackbird aircraft.

Goodyear Aerospace Corporation (now Lockheed Martin Tactical Defense Systems) built the MPP for GSFC based on research by David Schaefer (now associate professor of electrical and computer engineering at George Mason University, Fairfax, Virginia), James Strong (recently retired from the Applied Information Sciences Branch), Ken Batcher (now professor of mathematical sciences at Kent State University, Kent, Ohio), and Michael Fung. The 16,384-processor computer was the most powerful massively parallel system of its time, capable of 250 million floating-point operations per second.

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This Massively Parallel Processor has joined the Smithsonian Institute's National Air and Space Museum

Feature

Framework for Collaborative Steering of Scientific Applications

Beth Schroeder, Greg Eisenhauer, Karsten Schwan, Jeremy Heiner, Vernard Martin, Song Zou, Jeffrey Vetter (College of Computing), Ray Wang and Fred Alyea (Department of Earth and Atmospheric Sciences), and Bill Ribarsky and Mary Trauner (Office of Information Technology), Georgia Institute of Technology

Complex computations can be made more effective and efficient if users can easily contribute to the solution process these computations encode. This article is meant as an introduction to the potential increase in functionality and performance gained by user interaction with such complex computations. Namely, considered here are systems in which users interact with high performance computational instruments, running on single and networked parallel machines, as if they were physically accessible laboratory instruments. Entire distributed laboratories can be constructed from sets of such computational instruments. Within this context, the intent is to facilitate both on-line interactions with single computational instruments and interactions among multiple scientists and multiple instruments located at physically distributed sites where scientists may have dissimilar areas of expertise [1].

With this research, and with the larger-scale Distributed Laboratories Project at the Georgia Institute of Technology [2], the aim is to improve the state of the art of interactive high performance computing for parallel and distributed applications on the variety of heterogeneous platforms now in common use by high performance computing users and researchers. Particularly, the goal is to develop a general framework for enhancing the interactivity of high performance applications. This framework contains general interactivity (i.e., online monitoring and steering) mechanisms with which high performance applications may be inspected and/or steered at runtime by algorithms, human users, or both; supports interchangeable visualizations run across heterogeneous and distributed hardware platforms, using a robust and portable data meta-format for transporting visualization content; supports the simultaneous interaction of multiple scientists with single large-scale computations; and permits collaboration via multiple computational instruments among scientists working in separate locations.

The remainder of this article introduces one of the parallel and distributed scientific applications used in this research. Interactions with a single computational instrument during its execution, typically referred to as interactive program steering[1], are then discussed. Finally, the use of multiple computational instruments by sets of end users, thereby moving from issues addressed in previous work toward interesting topics in future research, is discussed.

Atmospheric modeling

In collaboration with atmospheric scientists at Georgia Tech, a parallel and distributed global chemical transport model has been developed. This model uses assimilated windfields (derived from satellite observational data) for its transport calculations, and known chemical concentrations also derived from observational data for its chemistry calculations. Models like these are important tools for answering scientific questions concerning the stratospheric-tropospheric exchange mechanism or the distribution of species such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbon (HCFCs) and ozone.

This model contains 37 layers that represent segments of the Earth's atmosphere from the surface to approximately 50 km, with a horizontal resolution of 42 waves or 946 spectral values. The model's implementation uses a spectral approach to solve the transport equation for each species. Details of the model's solution approach, parallelization, performance results, and future plans concerning model development are described in [3]. A

1 Interactive steering may be defined as the 'on-line configuration of a program by algorithms or by human users, where the purpose of such configuration is to affect the program's execution behavior'.

sample interface for collaborative model steering, depicted in Figure 1, displays a latitudinal and longitudinal slice of the distribution of N_2O atoms in the atmosphere.

Interactivity framework

Figure 2 depicts a general interactivity framework for a complex high performance application. The Distributed Laboratories project includes support for all aspects of such applications, including visualizations, steering interfaces, data communication and analysis middleware, collaboration support, and application monitoring and steering support. Before discussing the general issues in distributed collaborative applications, the focus is more narrowly on the framework required to support a single user interacting effectively with a single computational instrument. Specifically considered are the support required to efficiently monitor system-and application-level behavior in parallel and distributed programs; frameworks and support for steering such a program though external interfaces; and visualization interfaces for both monitoring and steering.

Monitoring

Interacting with computational instruments in terms meaningful to end users requires on-line monitoring—the dynamic gathering of application-specific information from an instrument as it executes. Falcon [4] is a set of tools and libraries supporting on-line, application-specific, event-based monitoring of parallel and distributed applications. Falcon consists of a sensor specification language and compiler for generating application sensors, and one or more local agents for on-line information capture, collection, filtering, and analysis of event data. In addition, Falcon uses intermediate monitoring/steering middleware to disseminate monitoring events to the potentially large number of clients that wish to interact.

Falcon's implementation is based on a local agent, usually residing on the monitored program's machine, to capture event data. On shared memory architectures, this local agent may be an additional thread operating in the instrument's address space. Local agents, due to their proximity to the computational instrument, can gather monitoring data quickly while minimizing interference with the instrument's operation. For physically distributed instruments, multiple local agents are employed and each of the instrument components is treated as a separately monitored entity.

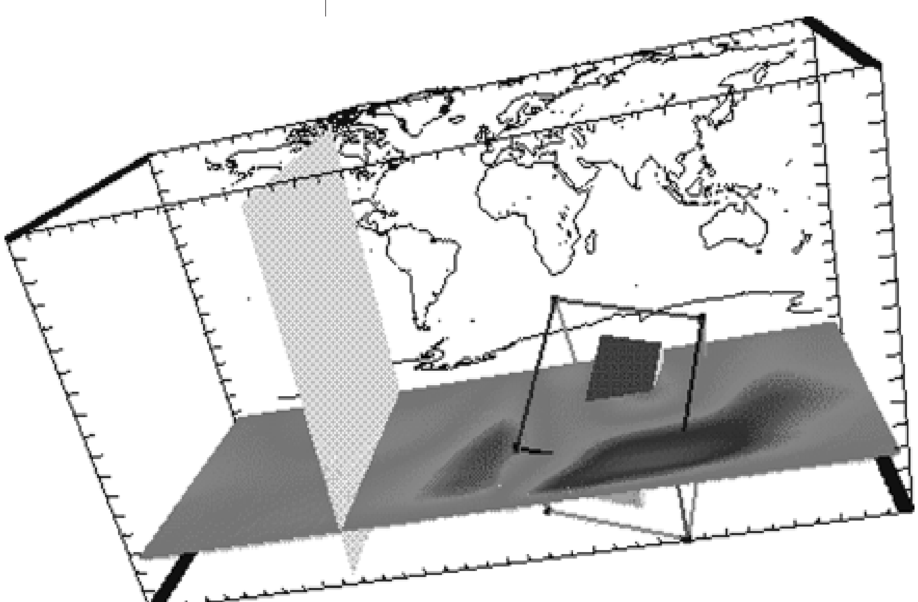

Figure 1. Three dimensional visualization of atmospheric modeling data

Interactive steering

A steering system used by external agents must have the following functionality:

1) receiving the computational instrument's runtime information from the on-line monitoring system
2) analyzing and then displaying the information to the end user or submitting it to a steering agent
3) accepting steering commands from the user or agent
4) enacting those commands to affect the application's execution

In Falcon's implementation of computational steering, at least one local agent runs on the target machine with the application. This local steering agent performs any steering actions requested by external agents. External agents are driven by monitoring data and may request steering actions directly based on this data or they may support graphical interfaces and request steering actions in response to user manipulations.

One insight from this experience with interactive steering is that computational instruments differ in terms of the ease with which certain steering actions may be implemented. An instrument's implementation may permit some of its internal variables to be inspected and steered continuously, with little additional instrumentation of the code. However, in general potential improvements in performance or functionality by the addition of steering depend largely on an instrument's implementation and on the steering and monitoring actions required. Another insight is that program steering must consider overheads not relevant to performance monitoring, which tends to focus on the effects of program perturbation. These overheads are the perturbation to the application due to instrumentation for monitoring and steering, the latency of the monitoring to enactment feedback loop, and the costs of decision making part of this latency. Specifically for steering, the end-to-end latency of the monitoring to enactment feedback loop is a critical performance constraint when steering actions cannot be based on 'stale' monitoring data, or when such actions become inappropriate after some future program state has been passed.

Application-specific interfaces

While monitoring and steering support are essential for efficient, low-impact interactivity, it is often the final visual interface that determines the success and effectiveness of interactivity. The interactive 3D visualization of atmospheric modeling data shown in Figure 1 is constructed and used with a set of modules from the GlyphMaker display and steering system [5] (originally constructed with the SGI Explorer environment, and now being supported in the OpenInventor framework). These modules implement the functionality required by certain application-specific displays, in this case modules that convert monitoring data extracted from the computational instrument from its spectral form to a gridded form more suitable for visualization, and a module acting as a reader for converting the data being displayed to be printed on high the high resolution output devices used by atmospheric scientists (using the PV-Wave visualization system).

Using the 3D visualization shown in Figure 1, the atmospheric model is steered by first positioning the latitudinal and longitudinal planes, sizing and moving a rectangle to intersect a plane, then entering a specific desired concentration increment/decrement. The resulting set of new concentration values is forwarded from the visualization interface to the computational instrument via the aforementioned monitoring/steering infrastructure. The new concentration values are used as part of the next timestep taken by the model to result (hopefully) in improved model behavior.

In contrast to the 3D visualizations providing excellent overviews of model behavior, a complementary 2D steering interface operating with subsets of the atmospheric modeling application's data is shown in Figure 3. This interface's display presents the distribution of C14 at the single latitude of 2.8N. It has two logical parts: one for showing both the computed and the observed concentration values of C14 atoms in air to the end user, and the other for accepting steering requests from the user. The computed results of the C14 distribution are represented by the circle-encoded curve from atmospheric layer 0 to 37, which is updated for every model time step. The concentration of C14 actually observed at this point is represented by the triangle-encoded curve. This may be indicative of a weakness or inaccuracy in the model that could be corrected by modifying some of its experimental values. When noticeable discrepancies such as these are detected, you can dynamically modify the application execution to 'correct' the computations.

While monitoring and steering support are essential for efficient, low-impact interactivity, it is often the final visual interface that determines the success and effectiveness of interactivity.

Toward distributed laboratories

Distributed laboratories are environments where scientists and engineers working in geographically separated locations share access to interactive visualization tools and large-scale simulation computations, share information generated by such instruments, and collaborate across time and space to evaluate and discuss their results. The intent is to permit scientists, engineers, and managers at geographically distinct locations (including individuals telecommuting from home) to combine their expertise in solving shared problems by allowing them to simultaneously view, interact with, and steer sophisticated computation instruments executing on high performance distributed platforms.

The underlying, enabling technologies needed to support distributed laboratories research include dynamic monitoring, adaption, and interactive steering of high performance computations, interconnectivity and data exchange infrastructure, and collaboration and shared visualization technologies. Novel communications and data analysis middleware facilitating on-line monitoring and interactive steering in a multi-scientist/multi-instrument environment are discussed in the following sections.

Middleware

A characteristic of distributed laboratories is that tools and experimenters may come and go dynamically and may be interested in different types of data at different times. Additionally, the various programs that cooperate to make up a distributed laboratory may not all be under the control of a single group, compiled by the same compiler or written in the same language. These characteristics impose needs on the communications and data analysis middleware that are addressed by two novel communication libraries, called DataExchange and Portable Binary Input Output (PBIO). These libraries provide a communications infrastructure that allows instruments, data analysis tools, and interactive client displays and visualization displays to be plugged into the system dynamically. First, the PBIO [6] library supports the transmission of binary records between heterogeneous machines. PBIO is essentially a data meta-representation. You register the structure of the data you wish to transmit or receive, and PBIO transparently masks the representation differences across heterogeneous machine architectures. In particular, PBIO handles differences in the sizes, locations and even basic types of the fields in the records to be exchanged.

While PBIO supports exchanging data between two clients, the DataExchange library [7] layered on top of PBIO provides support for establishing communication between agents, for resolving differences between data formats used by multiple agents, for forwarding data from agent to agent, and for processing data within an agent. DataExchange allows application handler functions to be bound to the arrival of new data so the DataExchange library augmented with a few application functions can thus serve as a configurable data filter, dramatically simplifying the task of creating networks of cooperating agents that gather, analyze, and distribute the data required for displays.

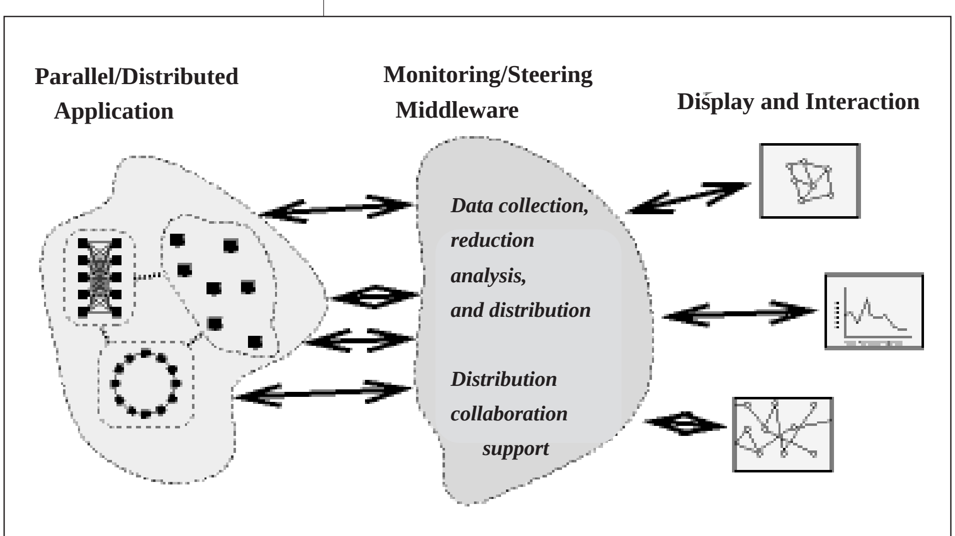

Figure 2. General interactivity framework

Goals and conclusions

A goal of distributed laboratories is to provide a mechanism for end users to jointly manipulate shared instruments. This goal is being realized in joint work with visualization and computer-supported-cooperative-work researchers, where mechanisms for coordinating what is rendered on separate machines and abstractions for manipulating shared complex entities are being developed. The goal is to create a framework and collaboration library with which application-specific interaction and collaboration abstractions are easily constructed, thereby removing some of this burden from the developer. The method used to attain this goal is to add means for constructing relevant ‘interactors’ as part of the data visualizations being employed by end users.

Specific research efforts that address the topic of interactive high performance programs are being undertaken at Georgia Tech. Some of them are:

1) the Falcon steering and monitoring tools and infrastructure are used in the on-line observation and manipulation of scientific computations
2) the DataExchange and PBIO middleware serve to transport the events and their contents used when observing high performance applications and when steering them
3) the visualization support provided by the GlyphMaker tool permits the definition of

appropriate visual abstractions and their efficient representation on 3D graphical displays

4) collaboration infrastructure and abstractions are provided using the OpenInventor graphical display framework

The Distributed Laboratories Project aims to construct an infrastructure with which future scientists and engineers can interact with each other and with their computational instruments as if they were physically co-located in a single laboratory.

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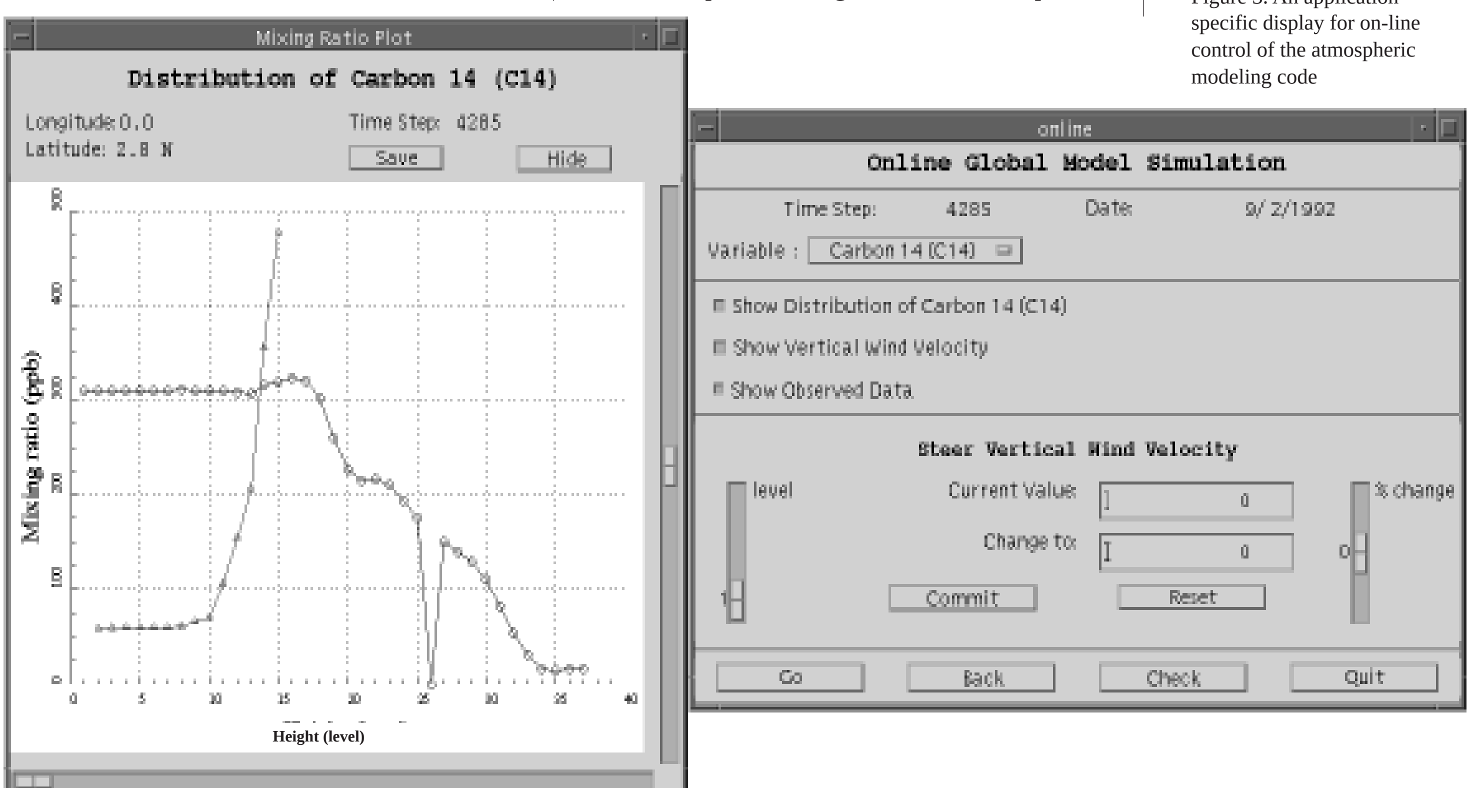

Figure 3. An application-specific display for on-line control of the atmospheric modeling code

Feature

Digital Library Technologies Enhance the Global Legal Information System

Susan Hoban, Center of Excellence in Space Data and Information Science, and Judy Laue, Hughes STX, Goddard Space Flight Center

The Global Legal Information Network (GLIN) is a partnership of countries promoting global access to legal information from all nations. GLIN enables member countries to post non-commercial databases of their laws and other legal information to the World Wide Web (WWW), and permits access by member countries to the entire legal digital library.

The GLIN currently consists of one repository, GLIN Central, located at the Library of Congress (LoC) in Washington, D.C. Member countries submit their legal documents in portable document format, with associated abstracts as ascii text. The legal documents typically are in the official language of the country, while, at this stage, the abstracts are required to be in English. Indexing currently is performed on the abstracts only. The system permits queries based on country of origin, publication or enactment date, or subject, based on a legal thesaurus provided by the Law LoC. The current archive consists of some 57,000 documents from 12 member countries, with more countries being added continually.

It is envisioned that by the year 2000 GLIN will provide fast, reliable on-line access to a distributed, global, digital legal library that contains the statutes and regulations of all participating countries.

Goddard Space Flight Center's (GSFC) Center of Excellence in Space Data and Information Science (CESDIS) has been involved in upgrading the GLIN Central site to reflect the state-of-the-art in WWW technology. The CESDIS enhancement of the GLIN system will result in a distributed repository, with any number of countries serving as regional GLIN nodes. When completed, the distributed GLIN archives are expected to be fully capable of capturing, processing, and distributing legal information in electronic format. The original sources of this information are protected through software security measures to preserve authenticity, and are available to authorized users in their official language. Abstracts and index terms will be offered as search tools in both English and the language of origin. Index terms will be extracted from a thesaurus built for each applicable language.

NASA's role in the GLIN project also has included consulting support on advanced data communications solutions that will be the common technology of the future. On September 5, 1996, in collaboration with the LoC, GSFC's Earth and Space Data Computing Division, Chief Milton Halem hosted a portion of the Third Annual GLIN Project Directors Meeting where a real-time demonstration of the Advanced Communications Technology Satellite (ACTS) was presented to over 50 international members of the GLIN project. ACTS is an example of leading-edge satellite technology that nations participating in GLIN can access from the commercial sector to gain faster and sometimes first-time Internet connection.

It is envisioned that by the year 2000, GLIN will provide fast, reliable, online access to a distributed, global, digital legal library that contains the statutes and regulations of all participating countries. GLIN will ensure the authenticity, accuracy, and currency of its collection of legal information using state-of-the-art information technology. GLIN members will have an understanding of advanced data communications solutions that could bring further advantages. The GLIN organization will be established as an international entity with the means and relationships to be financially self-sufficient.

For further information contact Susan Hoban at:

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Feature

NASA Internet FY96 Annual Report Now Available On-line

Pat Kaspar, NASA Internet, Ames Research Center

The NASA Internet (NI) Annual Project Report for Fiscal Year 1996 is now available online at:

http://nic.nasa.gov/ni/pjt-rpt-96/

The report highlights significant events, summarizes the progress made toward fulfilling NASA scientists' communications networking requirements, and establishes goals for the next fiscal year.

The Executive Summary examines the period since the last annual report in retrospect, highlighting such projects as Space Bridge to Russia Telemedicine, Internet protocol, multicast services, communications technologies prototyping, and interagency and international projects. Overview discusses the roles and responsibilities of the various functional groups within NI, and Metrics explains how NI measures its service, processes, and progress. Following Metrics are Interdisciplinary, which discusses NI's role in fulfilling both interdisciplinary and international requirements, and Outreach, which details NI's support for scientific conferences. The main body of the report, Discipline Review, covers NI's efforts in support of each NASA scientific discipline as well as NI's interdisciplinary accomplishments and outreach/conference activities. Finally, the Reference section includes the glossary, acronyms, points of contact, and requirements data base information. Statistics were derived from NI's requirements database and cover the period from September 1, 1995, through July 30, 1996.

For further information on this report contact Richard Dunn at:

rdunn@mail.arc.nasa.gov

For further information on NI access:

http://nic.nasa.gov/ni/

Visit This Web Site

The Applied Information Systems Research (AISR) program supports applied research in computer and information systems science and technology to enhance NASA's Office of Space Science (OSS) programs, maintains an awareness of emerging technologies applicable to space science disciplines, stimulates application development, and provides for the systems analysis and engineering required to transfer new technology into evolving OSS programs. To view the AISR homepage, access:

http://www.hq.nasa.gov/office/oss/aisr/aisrp.html

CORRECTION

In "Creating A New Web coastal Zone Color Scanner Browser", Issue 38, the name of the co-author, Ravi Kartan, was misspelled and his email was listed incorrectly. The correct email address is kartan@daac.gsfc.nasa.gov

Feature

Developing Internet Protocol Multicast Services

John Meylor, NASA Internet, Ames Research Center

The NASA Internet (NI) is involved in developing and deploying Internet protocol (IP) multicast services for all users. Multicasting is an IP standard that provides an efficient method for routing networked information to multiple users, passing only one copy along to any single network connection. As a result, multicasting utilizes significantly less bandwidth. However, because multicasting also requires routers to perform more complex routing processes, most routers throughout the global Internet (and NI) do not currently support multicasting. Instead, development multicast routers have been deployed. These routers form a virtual test network for multicasting called the multicast backbone, or MBone.

Besides providing a testbed for NASA's multicast services, NI also architects the global MBone routing at the Federal Internet Exchange/Metropolitan Area Exchange West (FIX/MAE-West) interexchange. NI currently maintains multicast feeds with over 14 other major network service providers, as well as feeds for Japan, Russia, and Antarctica. NI is also proactively involved in testing applications that are best suited for multicast routing, including multiway interactive multimedia applications such as those that support videoconferencing. NI collaborates with leading developers of multicast applications such as the Lawrence Berkeley Labs, Xerox Palo Alto Research Center, Information Sciences Institute, Silicon Graphics Inc, Cisco Systems, and many other public and private resource and development sources.

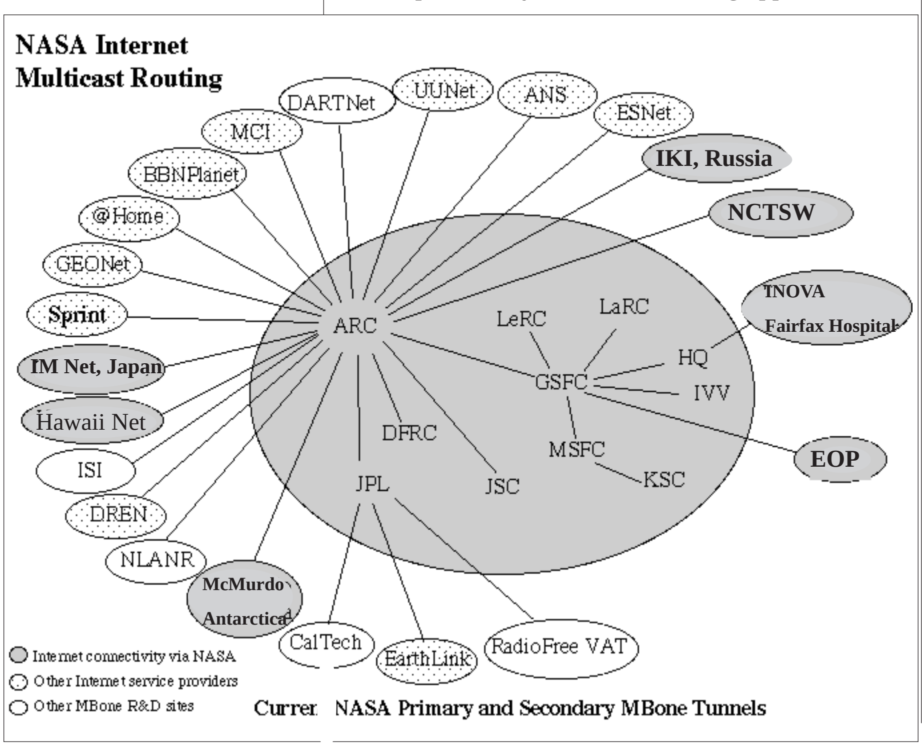
Although multicasting is not an operational service, several NASA projects have already benefited from the use of multicast services. The telemedicine project, part of the Office of Life and Microgravity Sciences and Applications, was able to use multicasting to successfully complete a series of medical consultations between physicians in the US and Russia. These consultations would not have been possible before multicasting was available. NASA also currently uses NI MBone services to regularly multicast live shuttle video and audio.

Testing of the multicast backbone and multicast-based videoconferencing is continuing and holds great promise for Internet-based collaboration among physicians, emergency disaster aid, and eventual space-based activities. Full deployment of production-mode multicast routing and multicast applications will allow NI users to achieve improved distribution of data without significant increase in cost for additional bandwidth. You will also be able to incorporate reliable multiway multimedia such as videoconferencing.

For further information contact the author at:

jmeylor@mail.arc.nasa.gov

Figure 1. NASA Internet Multicast Routing



Feature

NSCAT Educational CD-ROM Unveiled

Sugi Sorensen, Data Distribution Laboratory, Jet Propulsion Laboratory

The NASA Scatterometer (NSCAT) Educational CD-ROM, entitled *Winds of Change*, was released on August 16, 1996, at the NSCAT Launch and Educator's Conference. The conference, held at Jet Propulsion Laboratory (JPL), brought middle and high school science teachers from the southern California together to learn about the NSCAT mission. At the end of the conference, conferees watched a live broadcast of the launch of the Advanced Earth Observing Satellite (ADEOS-I) from Tanegashima, Japan. NSCAT, built by JPL, is one of several Earth-observing instruments mounted on the ADEOS spacecraft. After the launch, teachers were shown a demonstration of the CD-ROM by Gil Yanow of the JPL Educational Affairs Office.

Winds of Change was developed by the Data Distribution Laboratory (DDL) for the NSCAT Project Office as the centerpiece of their educational outreach activities. As well as providing information about the NSCAT instrument and mission, the CD-ROM is a science curriculum resource for middle school teachers. Focusing on the topic of the Earth's global climate, the disk contains over 200 images, about 45 minutes of video and animation, and 136 classroom activities and background information files in Adobe Acrobat format. The curriculum material was developed by professional curriculum writers both at JPL and from outside educational institutions.

Emphasis on curriculum

The NSCAT CD-ROM was designed to focus on its curriculum content. As an educational outreach product, this CD-ROM is a departure from most products prepared by JPL and other NASA projects. Traditionally, projects prepare special products such as slide sets, color prints, video tapes, and CD-ROMs that are narrowly focused in their subject matter and supplemental to subjects traditionally taught in the schools. To avoid this, the creators of the NSCAT CD-ROM decided to make a curriculum resource product and integrate it with existing teaching standards. They organized the curriculum material in accordance with state and national science teaching standards and created the web structure around the American Association for the Advancement of Science's "Benchmarks for Science Literacy" and the California Department of Education's "Science Framework for California Public Schools." The California standard was chosen because California was one of the first states to develop and incorporate teaching standards and has served as a model for many other states.

This CD-ROM is also unique because it does not impose a rigid structure or syllabus for how the curriculum material is to be taught. As a curriculum resource, teachers can freely navigate the CD-ROM and select what material to use, in whatever fashion they deem appropriate.

This CD-ROM is also unique because it does not impose a rigid structure or syllabus for how the curriculum material is to be taught.

Technical design

Technical design and implementation of the NSCAT CD-ROM was performed by JPL's DDL, which has developed other multimedia educational CD-ROMs such as *Welcome to the Planets* and the *TOPEX/Poseidon Informational CD-ROM.*

Designers, who were faced with the challenge of creating a curriculum resource for the *Winds of Change* that would be useful to both middle school teachers and students, worked closely with middle school science teachers. Because the CD-ROM was to be designed as a resource, it was decided early on to concentrate on the presentation of and access to its curriculum materials. Interactive computer activities were intentionally left off of the disk in favor of printable resource material such as images and classroom activities. Another, early challenge was choosing a format for the curriculum files, which comprise the heart of the disk. The disk's curriculum advisors wanted teachers to be able to browse the curriculum files on the computer, and print out formatted files suitable for distribution in the classroom.

Several standards were evaluated during the design process. Following on its previous work, the DDL staff chose Macromedia Director as its multimedia authoring tool, primarily due to Director's ease of use and multi-platform compatibility. Director's weak printing capability precluded it's use as the medium for the curriculum files. Adobe's Acrobat technology was chosen instead. The widespread use, on the World Wide Web, of the Acrobat Portable Document Format (PDF) for compound documents was a significant factor in its ultimate selection. Acrobat Reader viewers are available for free from Adobe for all of the major computer platforms and are provided on the disk. Although development was conducted almost exclusively on the Macintosh, the NSCAT CD-ROM runs on both Macintosh and Windows computers.

Technical innovations

The NSCAT CD-ROM's main application provides a point-and-click interface to the disk's contents: the NSCAT Mission, the Global Climate Curriculum, and a section on how to use the CD-ROM. Additionally, the CD-ROM contains several innovative features not typically found on educational products of this type.

First, to address the different ways teachers research and prepare classroom lectures, an architecture that provides several means of accessing its materials was implemented. Traditional point-and-click browsing of the disk in a hierarchical fashion or through hypertext links is the primary navigation mode. An interactive table of contents was also developed to allow quick access to any section of the CD-ROM, no matter how many levels deep. A third method of accessing information is through keyword searches. You can search all of the materials on the disk, including images and movies. A search engine utilizing a binary search algorithm was written in Lingo, Director's internal scripting language, to allow keyword searches. Four types of information can be searched: on-screen information, images, movies, and curriculum files. In order to allow effective searches of non-text data types (i.e. images and movies), description files were created and indexed along with caption files. This capability has been found to be beneficial to teachers. For example, a science teacher teaching about hurricanes can find all the images or QuickTime movies on the CD-ROM that show hurricanes.

Another feature requested by teachers was the ability to copy any of the resources on the CD-ROM for use in the classroom. Once again, subroutines were written in Lingo that allow copying of images, movies, or curriculum files to hard drives. Images are stored in the PICT image file format, and movies in the QuickTime format. Both of these formats are commonplace and readily importable into almost every word processing and graphics program available for Macintosh or Windows.

Yet another technical innovation, one that is transparent to the user, is the overall program architecture, designed to be easily reconfigurable. Most primary data elements such as images, movies, thumbnail images, curriculum files, and image and movie captions are kept external from the main Director program. Even descriptions of the content structure are kept external from the main program in ASCII-readable metafiles.

During run-time, the main Director program opens the metafiles, reads the contents, and stores the content description in memory. Then, as needed, resource elements such as images and their captions are opened and loaded into the main program for display. This generic architecture serves several advantages over traditional Director-authored movie files. For example, the content is easily reconfigured. Changes only need to be made to the external content file and the appropriate meta-description file(s). Traditionally, a developer would have to make these changes within the Director authoring environment.

Also, the architecture allows easy access to the individual content files. Since all of the images and movies are stored external from the Director program on the CD-ROM, you can easily copy files to your local hard drive. Construction of web-versions of the Director program are easier. Increasingly, DDL customers want both CD-ROM and web versions of educational products. Storing the content files external to Director allows for an easier transition to the web. The only required steps are converting the content files to web-compatible formats (e.g. PICT images must first be converted to GIF or JPEG), and generating a hypertext markup language version of the Director main program.

Finally, re-use of the Director program engine for other CD-ROM products was facilitated. The Director program engine used on the NSCAT CD-ROM is currently being used in two new educational CD-ROM products, the *Cassini Educational CD-ROM* and the *Magellan Venus Book Companion*.

Conclusion

Feedback to date from both students and teachers using the NSCAT Educational CD-ROM has been positive. Educators have remarked that it is an innovative educational tool that is useful in the classroom since its curriculum conforms to accepted standards. Student have indicated that the CD-ROM allows self-paced discovery learning of topics about both global climate and the NSCAT mission.

Over 5000 copies of the CD-ROM were produced for the NSCAT project and distribution is currently being facilitated by JPL's Educational Affairs Office. Copies of the CD-ROM are available free of charge to teachers and others in the educational field. Additional distribution will be provided through NASA's Teacher Resource Centers and NASA Central Operation of Resources for Educators (CORE).

For further information on *Winds of Change* or to receive a copy, access the Web site or contact the JPL Educational Affairs Office at, respectively:

http://stargate.jpl.gov/ support
818-354-8252

Acknowledgments

This CD-ROM was developed jointly by the DDL, NSCAT Project, JPL Educational Affairs Office, and professional educators and curriculum writers from the southern California area.Team participants are:

- *Curriculum Development team—Gil Yanow, JPL Educational Affairs office (lead); Ken Yanow, Bruce Payne, and Gil Yanow, (writers)*
- *Editor—Merrie Sasaki*
- *Original Concept—Firouz Naderi, NSCAT project*
- *Principal NSCAT Contributors—Chet Sasaki, Jim Graf, and Don Montgomery, with invaluable support from Gracie Hallowell, Steve Gunter, Randy Foehner, and Kevin Burke*
- *DDL Development Team—Sugi Sorensen (lead developer, programmer, animation support), Randii Oliver (animation and illustration), Vicky Barlow (researcher and content coordinator), Adrian Godoy (programming support), Margaret Cribbs (narration), and Yolanda Oliver (project management), with additional animation and 3D modeling provided by Don Davis*
- *Research Assistance—Anita Sohus*
- *Other Content Contributors—Danette Klein, David Hinkle, Carol Lachata, Kristy Kawasaki, Chris Finch, Suzanne Garcia, Mike Martin, Sue Hess, Sanjay Moorthy, and Adriane Jache*

Have You Been Published Lately?

NASA/Office of Space Science is proud of the contributions many of its science and applications researchers, scientists, and engineers make to professional organizations and publications. If you have been published in the last six months and wish to be noted in this newsletter, send the citation to sandi.beck@jpl.nasa.gov

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http://www-sisn.jpl.nasa.gov

and subscribe to receive automatic notification of each new issue as it comes on-line.

Feature

Studying the Earth as an Integrated System

> ***The key to understanding our global environment is exploring how air, land, water, and life interact.***

Earth's environment is constantly changing. Some changes are rapid and violent (hurricanes and tornados) while others occur suddenly, a result of a buildup of pressure in the Earth's crust (earthquakes and volcanoes). Besides these natural disasters, scientific research shows that changes to the Earth are being accelerated by human activity. Production of chemicals affects the ozone layer. Industrialization and deforestation precipitates global warming. Population growth necessitates increased agriculture, while land degradation, soil erosion, and climate variations threaten food production. The potential hazards of climate warming, rising sea level, deforestation, ozone depletion, and acid rain, to name just a few, have a profound impact on all nations. Therefore, international cooperation is important; supporting reseach and sharing data contribute to understanding global change. This understanding provides an objective basis for decision making.

The key to understanding our global environment is exploring how air, land, water, and life interact. The US Global Change Research Program (USGCRP), along with the International Geosphere-Biosphere Program (IGBP), and the World Climate Research Program (WCRP), is coordinating national and international scientific communities to explore the Earth's science systems: meteorology, oceanography, atmospheric science, and biology. Unique perspectives of these science systems can be acquired through space observations via satellites and aircraft that can look at all parts of the Earth.

NASA has been conducting space observations of weather, oceans, land surfaces, earthquakes, and the ozone for 30 years. In 1960 NASA launched the first weather satellite and continues to build US civilian weather satellites. From 1978-86, NASA instruments measured plant life productivity in the ocean. In 1985, a NASA satellite instrument confirmed the existence of the ozone hole over the Antarctic. Landsat data was used to analyze deforestation in Brazil and the Chesapeake Bay. Joint programs with Italy have provided scientists with the ability to track movements of the Earth's surface for nearly 20 years, which has increased the understanding of earthquakes. In 1991 NASA launched Mission to Planet Earth (MTPE), an international, cooperative program to study the Earth as an environmental system.

Mission to Planet Earth

MTPE is comprised of a series of satellites that are complemented by various airborne and ground-based studies. The science objectives of MTPE are to observe hydrologic, biogeochemical, atmospheric, ecological, and geophysical processes. The goal of MTPE is to promote scientifc understanding of the Earth's systems.

The objectives and the goal of MTPE will be pursued in three phases. Phase I (1990 to 1998) utilizes free-flying satellites (both NASA and non-NASA) from the US and from the US in concert with other countries (France, Italy, Japan), and space shuttle missions.

In Phase II (1998 to 2014) the Earth Observing Satellites (EOS), the centerpiece of MPTE, will be launched. EOS is composed of polar-orbiting and low-inclination satellites, an advanced data system, and teams of scientists to analyze the data. NASA's Earth-observing satellites, along with platforms from Europe, Japan, and the US National Oceanic Atmospheric Administration will form the basis for a comprehensive observation system, called the International Earth Observing System (IEOS), that will operate for approximately 15 years. IEOS will allow scientists to obtain detailed information on all major Earth system processes.

The EOS Data and Information Sytem (EOSDIS) will receive, process, store, and distribute data and information on key areas of study, such as water and energy cycles, oceans, the chemistry of the atmosphere, land surfaces, water and ecosystem processes, glaciers and polar ice sheets, and the solid Earth. Access to EOSDIS will be available to NASA's international partners, global change researchers, educators, and policy makers.

Phase III will continue MTPE well into the next century. Plans include satellites in geostationary orbit and additional small Earth Probe satellites to address specific Earth science investigations.

Some current data

Almost daily, NASA press releases announce new information collected from the currently operational space-based components of MTPE's Phase I. For example, the US Total Ozone Mapping Spectrometer (TOMS) instrument aboard the Japanese Advanced Earth Observing Satellite (ADEOS) just acquired the first image of the Earth's ozone layer globally mapped from space on September 12, 1996. ADEOS is an international global change research mission of the National Space Development Agency of Japan (NASDA) that includes instruments from the US, Japan, and France, with investigators from many other countries. William Townsend, the acting associate administrator for MTPE, explained that ADEOS is the first in a series of major collaborative efforts between NASA and NASDA in the area of Earth remote-sensing.

"As such, it is a superb example of increasing international cooperation between the United States and other spacefaring nations of the world in generating a better understanding of our planet and its complex climate," he said.

ADEOS continues the series of TOMS total ozone and volcanic sulfur dioxide observations that began with the Nimbus-7 satellite in 1978, and continued through the operation of a TOMS on a Russian Meteor-3 satellite, until that instrument ceased functioning in December 1994. TOMS helped make "ozone" a household word, during its lifetime on Nimbus-7, through its false-color images of the Antarctic ozone hole. Even after 14 years of operating the instruments, TOMS scientists are testing new concepts such as the monitoring of absorbing aerosols that are produced in fires, duststorms, and volcanic eruptions, estimation of ultraviolet (UV-B) radiation at Earth's surface, and detection of volcanic hazards to aviation.

TOMS measures ozone by comparing the level of ultraviolet light emitted by the Sun to that scattered from the Earth's atmosphere back to the satellite. In recent years, the depleting effects of industrial chlorofluorocarbons (CFCs) on ozone were demonstrated through the sudden appearance of the Antarctic ozone hole and other, more gradual losses in global ozone. The principal mission of TOMS/ADEOS is to monitor global ozone trends during the period when CFC-related depletion is predicted to be near its maximum.

Data from another TOMS instrument flying on the recently launched NASA TOMS-Earth Probe spacecraft complements the global ADEOS data by providing high-resolution imagery of atmospheric features related to urban pollution, biomass burning, forest fires, desert dust, and small volcanic eruptions, in addition to ozone measurement. TOMS will also provide information to help correct data from the Ocean Color and Temperature Scanner for atmospheric absorption at visible wavelengths.

ADEOS is also carrying the NASA Scatterometer (NSCAT), a US instrument designed to measure global ocean surface winds. Taking advantage of the natural reflection, or "backscattering," of radar pulses by wind-driven ripples in ocean waves, NSCAT will make 190,000 measurements per day of the speed and direction of winds within about 1.5 inches of the ocean surface. These winds directly affect the turbulent exchanges of heat, moisture, and greenhouse gases between the atmosphere and the ocean. These air-sea exchanges, in turn, help determine regional weather patterns and shape global climate. NSCAT will cover more than 90 percent of the globe every two days and will provide more than 100 times the amount of ocean wind information currently available from ship reports. Since NSCAT is a radar instrument, it is capable of taking data day and night, regardless of sunlight or weather conditions.

"NASA researchers will use the data to understand the interface between the Earth's two great fluids: the oceans and the atmosphere," said Jim Graf, NSCAT project manager at JPL. "Understanding and characterizing this interface is critical to better scientific understanding of global warming, El Nino phenomenon, and other studies of the Earth as a total system. In addition, seafaring organizations that transport goods and passengers across the oceans can use the data from NSCAT to steer their ships more safely and economically."

Susan Zevin, deputy director for the National Weather Service, an agency of the National Oceanic and Atmospheric Administration, explained that data from both TOMS and NSCAT are valuable to the weather service. The ozone data will be used to monitor volcanic ash in the atmosphere, which will improve aviation safety, and to help generate a daily forecast of ultraviolet exposure levels to help reduce peoples' overexposure to the Sun's rays. Data from NSCAT will help local weather forecasters more accurately predict the path and intensity of hurricanes, winter storms and other weather systems that form over the oceans.

Another satellite, TOPEX/Poseidon, a joint venture with France, is helping marine biologists locate and count sperm whales and dolphins. TOPEX/Poseidon uses altimeters to bounce radar signals off the ocean's surface to get precise measurements of the distance between the satellite and the sea surface. These data are combined with measurements from the European Space Agency's ERS-2 instruments that pinpoint the satellite's exact location in space. These data are used in near-real-time to generate circulation feature maps that are then faxed to a research ship, R/VGyre, in the Gulf of Mexico. These maps provide the onboard scientist with timely information about rapidly changing ocean features so that the ship can be directed toward those areas to determine if whales and dolphins are present.

There is evidence that whales prefer to feed in the edges of cyclonic eddies, and the satellite data gives us a good picture of where those oceanographic features are located," said George Born, a principal investigator on the TOPEX/Poseidon project from the University of Colorado at Boulder.

A Co-principal Investigator, Robert Leben, stated that the data from both TOPEX/Poseidon and ERS-2 greatly enhance the ability to identify and map circulation features as they occur in the Gulf. A previous survey indicated that whales and dolphins were encountered most frequently in the area where warm water eddies break off from the Gulf Loop Current, a strong ocean current that circulates around that Gulf.

Every ten days, scientists are able to produce a complete map of global ocean topography; the barely perceptible hills and valleys found on the sea surface. With detailed knowledge of ocean topography, scientists can then calculate the speed and direction of worldwide ocean currents. An unexpected benefit for marine biologists, according to Lee-Lueng Fu, a project scientist at JPL, is that scientists are able to study not only ocean currents, but the creatures that inhabit the oceans as well.

Randall Davis, head of the Marine Biology department at Texas A&M University at Galveston explained the objective of the R/V Gyre expedition, which is sponsored by Texas A&M University, the Texas Institute of Oceanography, and the National Biological Service. "The goal of our cruise," he said, "is to make a visual and acoustic census of marine mammals and to define their physical and biological habitat in the northeastern Gulf in areas potentially affected by oil and gas activities now or in the future."

These are just selected examples of information acquired by MTPE satellites. You may keep abreast of these Earth observing studies by visiting the MTPE home page on the World Wide Web.

For further information on MTPE access:

http://www.hq.nasa.gov/office/mtpe/

Excerpted from the 1995 MTPE EOS Reference Handbook *and the* 1995 Fact Book—Understanding Our Changing Planet: NASA's Mission to Planet Earth. *Information on TOMS was excerpted from NASA press release 96-188, written by Allen Kenitzer, GSFC, and Hideo Hasegawa/Hiroyuki, Ikenono, NASDA, Tokyo, Japan. Information on NSCAT was excerpted from NASA press release 96-165, written by Allen Kenitzer, GSFC, and Mary Hardin, JPL. Information on TOPEX/POSEIDON, was excerpted from NASA press release 96-209, written by Mary Hardin, JPL, Dirk Martin, University of Colorado at Boulder, and John Merritt, Texas A&M University, Galveston, Texas.*

Feature

NASA Awards Funds for Supercomputing Applications

Jarrett Cohen, Hughes STX, Goddard Space Flight Center

NASA-funded development of Grand Challenge supercomputer applications, 10 times faster than today, will provide a new understanding of the fundamental problems in the Earth and space sciences.

A $25.8 million set of cooperative agreements is supporting collaboration among NASA, nine investigator teams, and Cray Research (a business unit of Silicon Graphics, Inc.) of Eagan, Minnesota, to achieve advances in supercomputing applications. The challenges being pursued include modeling changes in global climate and the Earth's interior, simulating the evolution and dynamics of stars, probing microgravity environments, and processing remote sensing imagery and signals. For broader benefit, the new computer programs and documentation will be made available to the research community on the the World Wide Web's (WWW) National High Performance Computing and Communications (HPCC) Software Exchange at:

http://nhse.cs.utk.edu/home.html

The three-year agreements are funded through the Earth and Space Sciences (ESS) Project of NASA's HPCC Program.

Science advances will be enabled by a 384-processor CRAY T3E supercomputer being placed at NASA's Goddard Space Flight Center, Greenbelt, Maryland, as part of a $13.2 million agreement with Cray Research. "With 49 billion bytes of memory and 230 billion floating-point operations per second peak performance, this system will be NASA's leading testbed for scalable parallel computing, in which a program's speed increases proportionally with the number of processors," said James Fischer, ESS Project Manager. Cray Research subsequently will assemble a CRAY T3E as large as ,024 processors to allow 100 billion floating-point operations per second sustained on investigator applications.

"This effort will further the Earth and space sciences by helping to overcome one of high-performance computing's greatest bottlenecks—the lack of usable software for parallel machines," said Lee Holcomb, director, Aviation Systems Technology Division at NASA Headquarters, Washington, D.C. "Such computational studies strongly mesh with NASA's observational and theoretical programs and contribute to our wider mission of scientific research and space exploration."

Funded investigations

The investigations encompass 86 researchers at 22 US universities and six federal laboratories. The research topics are:

- Three Dimensional Spherical Simulations of the Earth's Core and Mantle Dynamics—a cooperative agreement with Johns Hopkins University, Baltimore. Peter Olson of the Department of Earth and Planetary Sciences is the principal investigator. The team will simulate the chaotic processes that drive the evolution of the planet's interior, and in turn shape its surface, over timescales ranging from hundreds to millions of year.
- Advanced Computing Technology Applications to SAR Interferometry and Imaging Science—a cooperative agreement with the Jet Propulsion Laboratory (JPL), Pasadena, California. David Curkendall of the Center for Space Microelectronics Technology is the principal investigator. Use of multiple supercomputers to process and visualize satellite-collected synthetic aperture radar data will allow close monitoring of regional changes in alpine glaciers, plate tectonics, and rain forests.
- Four Dimensional Data Assimilation—Investigation of High Performance Computing and Current Algorithms at Goddard Data Assimilation Office—a cooperative agreement with the University

of Maryland, College Park. Peter Lyster of the Department of Meteorology is the principal investigator. The focus of this work is melding observations and climate model prediction into a robust data analysis scheme for NASA's Earth Observing System, thereby providing the most accurate possible picture of the atmosphere through space and time.

- Development of an Earth System Model—Atmosphere/Ocean Dynamics and Tracers Chemistry—a cooperative agreement with the University of California, Los Angeles. Carlos Mechoso of the Department of Atmospheric Sciences is the principal investigator. Aimed at realistic portrayal of the Earth's climate, this effort will develop and couple four highly complex models with high spatial resolutions: atmospheric general circulation, oceanic general circulation, atmospheric chemistry, and oceanic chemistry.
- Scalable Parallel Finite Element Computations of Rayleigh-Benard-Marangoni Problems in a Microgravity Environment—a cooperative agreement with the University of Texas, Austin. Graham Carey of the Department of Aerospace Engineering and Engineering Mechanics is the principal investigator. Modeling of fluid flows in low gravity environments will test the effectiveness of manufacturing higher quality thin films and coating processes in space and the functioning of the space station's life support and safety systems.
- Turbulent Convection and Dynamos in Stars—a cooperative agreement with the University of Chicago. Andrea Malagoli of the Department of Astronomy and Astrophysics is the principal investigator. This group will study some of the most fundamental and least understood turbulent processes in the interior of stars like the Sun, whose dynamics are only beginning to be inferred from new space probe and Earth-based observations.
- Understanding Solar Activity and Heliospheric Dynamics—a cooperative agreement with the Naval Research Laboratory, Washington, D.C. John Gardner of the Laboratory for Computational Physics and Fluid Dynamics is the principal investigator. As NASA observations show their key role in the physics of solar activity, the tangled three-dimensional structures that develop in the magnetic field of the Sun's corona, or outermost layer, will be modeled.
- Parallel Adaptive Methods for Multiscale Modeling of the Heliosphere—a cooperative agreement with the University of Michigan, Ann Arbor. Tamas Gombosi of the Department of Atmospheric, Oceanic, and Space Sciences is the principal investigator. From the corona to the free-streaming interstellar medium, computational studies will be used to understand the interaction of the solar wind with galactic gases and plasmas, as well as with magnetized and unmagnetized bodies in the solar system.
- A Multipurpose Three Dimensional Code for Relativistic Astrophysics and Gravitational Wave Astronomy—Application to Coalescing Neutron Star Binaries—a cooperative agreement with the University of Michigan, Ann Arbor. Tamas Gombosi of the Department of Atmospheric, Oceanic, and Space Sciences is the principal investigator. From the corona to the free-streaming interstellar medium, computational studies will be used to understand the interaction of the solar wind with galactic gases and plasmas, as well as with magnetized and unmagnetized bodies in the solar system.

The supercomputer

In September, Cray Research placed an interim CRAY T3D system (the CRAY T3E's predecessor) with 512 processors and 32 billion bytes of memory at Goddard. By June 1997, NASA and the investigators will complete transition to the 384-processor CRAY T3E. Access to larger CRAY T3E systems will occur before the program's conclusion in 1999. Time on the computers will be divided among ESS Projects, NASA HPCC Computational Aerosciences Project investigations, and other NASA Earth and space sciences researchers.

For additional ESS Project information access:

http://sdcd.gsfc.nasa.gov/ESS/

Feature

NASA Participates in the "World's Largest" Computer Graphics Show

The 23rd Annual International Conference on Computer Graphics and Interactive Techniques, SIGGRAPH, was held in New Orleans (or N'Awlins, as the natives call it) this year, presenting state-of-the-art technology in graphic art, animation, applications, and interactivity. Nearly 25,000 people attended the lectures and discussions, courses, animator sketches, or application presentations; roamed the commercial exhibit or research exhibit venues; or participated in the educator's program. The "Bridge" and the "Art Market" presented computerized graphic art, and the show's highlight event, the Electronic Theater, presented film animations in New Orleans' historic auditorium.

Lecture topics ranged from illustrating to creating virtual environments. Classes were held on how to program graphics, virtual reality, or animation; create designs for the Internet; visualize scientific data; or pixelize cinematography—on beginning, intermediate, or advanced levels. The educator's program consisted of two tracks, Kindergarten Through Grade 12 and university. This training course for teachers focused on how to teach and apply computer graphics at every level.

Animator sketches provided an open discussion forum on creative and production problems, and novel techniques. The applications program, a new addition to traditional offerings, demonstrated theory-into-practice, "showing how computer graphics research from previous years has successfully migrated into the everyday working world."

This year's research venue featured interactive technologies. The "Digital Bayou", exuded hanging moss, weathered bayou shacks, and simulated crabbing baskets, offered networked virtual societies, teleoperation, innovative interfaces, and scientific visualization.

NASA participation

Jet Propulsion Laboratory (JPL) participated in the Digital Bayou with an exhibition of Earth and space science data visualization. The group from JPL's Science Data Processing Systems section demonstrated various interactive applications for processing and visualizing science data returned by instruments onboard spacecrafts in Earth orbit and on solar system exploratory missions. The daily demonstrations were of the Science Analysis Graphic Environment (SAGE), VISTAS, the Airborne Visible and Infra-Red Imaging Spectrometer (AVIRIS), the Atmospheric Infrared Sounder (AIRS), the Automated Speech Visualization (ASV) task, the Mars PathFinder (MPF) Rover simulation, the Remote Renderer, the Planetary Photojournal, the Mobile Underwater Debris Survey System (MUDDS), and Surveyor. Informational handouts on JPL visualization programs and current and back issues of this newsletter were also distributed.

SAGE is a graphical interface used to control processing of imaging and other science data returned by solar system exploration spacecraft. SAGE can be accessed on the World Wide Web (WWW) <http://rushmore.jpl.nasa.gov/sage>.

VISTAS is an interactive tool that supports the query and retrieval of remotely sensed Earth observation data. VISTAS software, used by Tiros Operational Vertical Sounder, can be anonymously file-transferred <ftp daac.gsfc.nasa.gov>.

AVIRIS is an airborne instrument that acquires high resolution imagery of the Earth's surface in 224 spectral bands, with wavelengths from 400 to 2500 nanometers. AVIRIS can be file-transferred from <ftp://ophelia.jpl.nasa.gov/README.htm>.

AIRS is a high-spectral-resolution infrared spectrometer that, together with the Advanced Microwave Sounding Unit and the Microwave Humidity Sounder, is designed to meet NASA's global change research objectives and the National Oceanic and Atmospheric Administration's operational weather prediction requirements. AIRS can be accessed on the WWW <http://www-AIRS.jpl.nasa.gov>.

ASV generates realistic animations of people speaking from video of the subjects saying other things. It is being developed for the military.

The MPF Rover simulation is a digital computational model of the actual rover and terrain, using computer-aided-design models, a terrain database, and physical dynamics models. To view a virtual reality modeling language version of the rover models used in this simulation, access <http://www-VESA/tma/roverModels.html>. For more information on the rover see page 15.

The Remote Renderer is a Web visualization tool. It is designed to give educators and students a means to visualize data collected by spaceborne platforms.

The Planetary Photojournal is a Web-based image browser aimed at a broad user community. It is designed to provide easy access to planetary images. To view the Photojournal access <http://photojournal.jpl.nasa.gov>. See page 51 for detailed information.

MUDDS incorporates data fusion and visualization tools for locating unexploded ordnance in shallow water areas. The Navy is developing a suite of sonars and other sensors whose data is processed and visualized using JPL-developed tools. MUDDS can be acessed at <http://www.ncsc.navy.mil/10t2/mudssint.htm>.

Surveyor is a tool used to create animated terrain-dataset "fly overs". This tool was developed in-house and is used by other institutions with a need to visualize data.

Three of the JPL exhibitors participated in the applications program. Jeff Hall, of the Visualization and Earth Science Applications group, presented "Animations from NASA's Explorations of Outer Space: Use of computer Graphics With Satellite Data." He spoke on the various methods for displaying and animating remotely sensed data. His emphasis was on putting the data into a context that is intuitive and useful to the viewer and on using computer graphics techniques to display data in a format meaningful to both the scientific community and the general public.

Dave Kagel (standing in for author Ken Scott, another member of Hall's group), spoke on speech visualization in Scott's talk "MaxHeadRoom of the 21st Century: Producing Realistic Talking Head Animations Using the Actors System." In this presentation Kagel explained how the application quickly produces realistic animations of a person speaking.

Bill Green, manager of the Science Data Processing Systems Section, gave a talk titled "Visualization of Earth and Space Science Data at JPL's Science Data Processing Section." He presented an overview of systems currently used to process, manipulate, and display remotely sensed imagery acquired by Earth observations and planetary exploration spacecraft.

New frontiers

SIGGRAPH '97, to be held in Los Angeles, California, is initiating the SIGGRAPH Student Activities program, an onsite, year-round, resource for educators and students. Lectures, tours presentations, field trips, and workshops will be a part of this evolving program. An online presence to link programs, local group activities, and participants internationally is planned. Additionally, the organizers hope to extend this event's reach far beyond the traditional computer graphics community by establishing new links with individuals, companies, and institutions throughout Los Angeles and southern California. They are especially interested in contributors who have never participated in a SIGGRAPH conference before.

For further information on SIGGRAPH email or access the website, respectively:

siggraph97@siggraph.org
http://www.siggraph.org/s97/

OUTREACH

Teachers Attend Virtual Training

Andrea McCurdy, Sterling Software, NASA Information Infrastructure Technology and Applications, Kindergarten Through Grade 12 Internet Initiative

> "I am flabbergasted with what I was able to do and learn today. I cannot wait to start the new year with this project. Thank You!" *—Teacher in Maine*
>
> "This is the single most exciting experience of my life—Mars Online you're brilliant."*—Student in Ireland*

These are quotes from remote webchat participants of the online Mars "Virtual" Teacher Training Conference held in Washington, D.C., July 20, 1996. Although these participants were hundreds, or even thousands, of miles away, they were able to view the activities of the D.C. conference and ask questions of the experts on stage.

The conference provided educators around the world with the same information and interactivity as those who were present at the conference. Two participants from each of the fifty states gathered in D.C. where they were shown how to integrate information about the upcoming missions to Mars into their curriculum. Additionally, over 140 sites in the US and 45 sites located in 12 other countries around the world were involved via the Internet. Remote participants were given the opportunity to view and listen to conference activities and to read transcripts and updates from the auditorium. Onsite teacher participants collected questions from the online audience and presented them to the experts on stage.

Attending teachers, local and online, were given personal access to Mars mission scientists and program directors from NASA HQ in Washington, D.C., and the Jet Propulsion Laboratory in Pasadena, California. They learned of the plans for the Mars missions, how these plans came to be, and about the many technical and social obstacles to bringing the plans to life.

A wide range of educators and educational institutions presented curriculum and classroom activities. The Technology and Education Research Center presented a unit on the use of Mars temperature data and a shoe-box rover project. A Mars Pathfinder Project educator provided a hands-on activity demonstrating Mars mountain and stream table activities as part of the Mars Canyon Module. The Planetary Society presented "Red Rover, Red Rover", a project that allows for remote control of a Mars rover model via the Internet.

A highlight of the day's activities was a review of Georgia Tech's Mars Navigator CD-ROM, which introduced "Matt", a lively character with an incredible knowledge of the universe and its planets, as well as of NASA launch vehicles and their missions. Additionally, Passport to Knowledge (PTK) and NASA's Kindergarten Through Grade 12 (K-12) Internet Initiative introduced the Live From Mars (LFM) project activities that will occur over the next two years.

Funding for the virtual conference was shared by PTK and NASA's Information Infrastructure Technology and Applications' K-12 Internet Initiative. PTK, a project supported by NASA, the National Science Foundation, and public television, coordinated the workshop content and brought the teachers together and will continue to support teachers around the world who take part in the LFM activities. Project coordination, technical direction, and some technical support was provided by NASA's K-12 Internet Initiative at Ames Research Center (ARC). Primary technical support came from a team located at NASA HQ, whose mission is to support the needs of NASA as it brings new and innovating uses of network technology to life.

For further information about Sharing NASA programs access:

http://quest.arc.nasa.gov/interactive

OUTREACH

The goal of NASA's many outreach programs is to promote to the general public an understanding of how the results of space science research make significant contributions to American education systems and to institutions dedicated to improving science literacy. This newsletter provides one vehicle for reporting how applications and hardware used for space science research and development can be adapted for use by teachers and their students and by non-NASA organizations.

Workshop Inspires School to Build Its Own computer

Judy Laue, Hughes STX, Goddard Space Flight Center

Date: Mon, 7 Oct. 1996
To: James Harrington
From: Trish Panknin
Subject: Advanced Network Strategies Workshop

I just had to write to let you know how excited we are at our shcool this year—and we owe it all to the workshop you sponsored! My teacher friends and I attended your workshop at TAMUCC this summer and I can't tell you what a difference it has made. Because of the knowledge and confidence we gained during that week, we will have new computers in our classrooms by next month!

After building comppputers at your workshop, we decided that we could do the same thing—with help, of course. We approached our district with the idea of building instead of buying computers. They listened and they liked what they heard. We worked together on specs and vendors, and now I think our administrative people are just as excited as our teachers.

We are scheduled to have this building session sometime in early November when we receive all the parts. Over the summer, we built a big support group of very knowledgeable people in our area (like Patrick Michaud) and they have all agreed to help us. Teachers at other schools have also heard what we are doing and they want to come help and learn. Our district is now considering using this approach for all new computer labs. However, they will probably get a company like Microstop to assemble them. As for us, we getting two rooms for what our district would have spent for one. We're happy and our administration is happy.

Thank you for bringing that workshop to Corpus Christi. It truly made a difference in our school.

Trish Panknin
Career & Technology Dept.
Richard King High School
Corpus Christi, Texas

This thank-you letter was written by a Corpus Christi, Texas, teacher to James Harrington, the Minority University-Space Interdisciplinary Network (MU-SPIN) program's workshop project manager. According to Panknin, Richard King High School and its district's representatives arranged to provide the high school with computers built from parts—a cost saving venture that promises to increase student access to computers. Moreover, the representatives are considering using this method to bring computers to all of the district's new computer labs. Panknin explained, "After building computers at your workshop, we decided that we could do the same thing—with help, of course."

The "Advanced Network Strategies: From Computer Building to Building Computer Networks" workshop was held July 21-26, 1996, at Texas A&M University-Corpus Christi (TAMUCC) in collaboration with Prairie View A&M University/NASA Southwest Regional Network Resources and Training Site and the MU-SPIN program. "Building PC Workstations," the hands-on tutorial that showed how to build computer systems from basic components, was originally intended to train participants in PC trouble-shooting and repair.

Other sessions held at this workshop covered a broad range of computer-related topics to enable colleges and individuals to establish and manage networks and servers, as well as to effectively use the Internet and World Wide Web (WWW). Workshop topics included the following:

- building PC workstations from basic components and installing software
- setting up Internet Protocol (Ethernet) networks to implement campus-wide networks
- managing Internet servers, creating WWW home pages, and using the Internet
- troubleshooting 10BaseT and TCP/IP networks and understanding network management
- using network protocol analyzers

Approximately 45 students, teachers, and administrators from more than 26 minority high schools, colleges, and universities attended the workshop.

For more information contact James Harrington at:

james@muspin.gsfc.nasa.gov

OUTREACH

"Live From Mars" Connects Teachers/Students With Scientists

Pat kaspar, NASA Internet, Ames Research Center

The Ames Research Center's (ARC) Kindergarten Through Grade 12 (K-12) Internet Initiative has developed a system by which NASA projects can conduct outreach activities and simultaneously give credit and visibility to their many behind-the-scenes workers. For the past three years, this group—a part of the Information Infrastructure Technology and Applications (IITA) program—has provided on-line projects such as "Live from the Stratosphere," "On-line from Jupiter," and "Live from the Hubble Space Telescope." These projects, collectively known as "Sharing NASA," strive to maximize the benefit to the educational community while minimizing the impact on NASA experts. These activities focus on bringing to life the scores of people behind the scenes through biographies, field journals and interaction with the participating children. While all of the Sharing NASA projects are conducted via the Internet, some of the projects are accompanied by live television broadcasts and are a collaboration with the "Passport to Knowledge" team led by Geoff Haines-Stiles Productions.

"The 'Live From. . .' activities bring exciting and exotic places into the classroom via television and teachers' guides," said Karen Traicoff, manager of the K-12 group.The challenge is to let educators know that, even without TV, these projects can be powerful educationally. They are an excellent outreach tool and an order of magnitude less expensive than projects that utilize live TV."

Traicoff explained that a good example of a project that had tremendous impact yet did not involve live TV was last winter's "On-line From Jupiter" that monitored the descent of the probe into Jupiter's atmosphere. The project caught the eye of British radio producers at the British Broadcasting Company who had actors and actresses read aloud the field journals during the climatic Jupiter arrival week.

Live From Mars

This school year, "Live From Mars" will follow the progress of two spacecraft as they head to Mars. The Mars Global Surveyor, launched in November of this year, will arrive at Mars in September 1997 where it will go into orbit studying the planet's surface, atmosphere, and gravitational and magnetic fields. A second spacecraft, Mars Pathfinder, launched in December 1996 and will arrive at Mars on July 4, 1997. Pathfinder will deploy a small rover to investigate the surface atmosphere and the geology and composition of Martian rocks and soil.

"Live From Mars will let teachers and students get to know the men and women who are sending the spacecraft to Mars," said Marc Siegel, the manager of Sharing NASA. "They will participate in hands-on activities through teachers' guides to help them understand science—why we are going and what it takes to go there. This project includes an on-line Internet component, live TV programs, and a teacher's guide with about 15 hands-on activities. There will be on-line opportunities for kids to interact with experts through email and through live CU-SeeMe and Web Chat sessions. Students will also gain an understanding of mission planning."

The Mars project engages students by having them mimic what spacecraft designers did before they sent the spacecraft out to Mars. At the beginning of the school year, classrooms decided what tools they would take along to measure their environment (e.g., camera, thermometer, barometer, PH tester for soil, shovel). In November they began an on-line debate with other students to help them reach a consensus on the best tools to take. They also had to design their instruments to be cheap, since they had to buy or borrow them. Throughout this process they will have learned to advocate, debate, convince, compromise, etc. The debates will end in December, and in January the students will collect their tools,

The Mars project engages students by having them mimic what spacecraft designers did before they sent the spacecraft out to Mars.

make their measurements, and share their results on-line. This is just one example of the various activities that will take place throughout the school year. According to Siegel, any school can participate without cost by accessing the URL:

http://quest.arc.nasa.gov/mars

Five TV programs will highlight the countdown, the trip between the planets, the touchdown, and Pathfinder discoveries. These programs, carried on the national Public Broadcasting System (PBS) and on NASA Select, began in November and will broadcast again in April, July, October and November of 1997.

Additional projects

In addition, other projects will be conducted during the 96-97 school year. For example, the Shuttle/Mir Online Research Experience project, known as “S/MORE”, is about the NASA life sciences research being conducted onboard the Mir space station. S/MORE is a partnership with ARC’s Space Life Sciences Outreach Program. Another project, “Women of NASA,” will provide students with an opportunity to meet some of NASA’s diverse scientific and technical women via live network interactions and an archive of biographies. Also provided will be resources for teachers who are trying to deal with the issue of gender-equity in their classrooms. This project is designed to encourage female involvement in math and science careers via role models within NASA.

The K-12 Internet Initiative is looking for NASA science research projects who want to do K-12 outreach. The typical cost for funding the on-line components (excluding the TV and teachers guides) is around $50K, and it takes around three months to arrange the support. “This is an excellent way for projects to give credit and recognition to all of the people involved,” said Traicoff, “not just the project managers and principal investigators.”

For information about the projects supported by NASA’s K-12 Internet Initiative or for specific information about the Sharing NASA programs, access, respectively:

http://quest.arc.nasa.gov
http://quest.arc.nasa.gov/interactive

To stay informed about upcoming projects, subscribe to the mail list by sending a message to:

listmanager@quest.arc.nasa.gov

In the body of the message write only the words “subscribe sharing-nasa.”

“Live From Mars” is a Passport to Knowledge project and is supported by the Mars Exploration Office at the Jet Propulsion Laboratory in partnership with the National Science Foundation and PBS. All on-line support is provided by the ARC-based K-12 Internet Initiative.

Honors and Awards

The KidSat Website received the “Fednet ‘96 Award for Networking Excellence” for the most innovative Website of 1996 from Webbie Internet Awards. Access the KidSat homepage at:

http://www.jpl.nasa.gov/kidsat

Also, the KidSat Data System Element Lead, Paul Andres, was honored for Space Flight Awareness for the KidSat Project. He was awarded a trip to Kennedy Space Center to attend a Shuttle launch.

"Communicating Science" Stretches the Imagination

Susan Lee, Sterling Software, Information Infrastructure Technology and Application Program, Ames Research Center

What if wearing a computer in the heel of your shoe would allow you to exchange email addresses by shaking hands?

What if the ink on the page was intelligent enough that it could rearrange itself and successively display a whole book?

What if the emotions in a sonata played on the cello by Yoyo Ma could be observed on video and comprehended by a machine using artificial intelligence?

These were examples of research being done at the Media Lab at Massachusetts Institute of Technology and the subject of the keynote address by Michael Hawley, professor of Media Technology, at the Communicating Science Conference held at NASA Headquarters this past September.

The conference was sponsored by NASA's Information Infrastructure Technology and Application (IITA) program and was the third annual conference for the Cooperative Agreements Principal Investigators (PIs) and Center Education Outreach team members. For this conference, the lobby of NASA headquarters became a sort of convention hall, filled each day with exhibits representing the three main areas of the IITA program: digital libraries, remote sensing data, and educational outreach. Simultaneously, website demonstrations and workshops on lessons learned were held in the auditorium. NASA headquarters staff were invited to tour the lobby displays, and PIs had the opportunity to meet and exchange ideas informally.

Charles Wood, PI at the University of North Dakota, said, "At the first conference we talked about our plans. Now we are talking about all of the things we have actually done."

Digital Library demonstrations included compression algorithms for image transmission, information retrieval mechanisms for handling teraFLOPS and petaFLOPS of graphical information, and kiosks to provide public access to remote sensing weather displays. Volcano World, Virtually Hawaii, and WeatherNet4 projects demonstrated how remote sensing data is being provided to the public via the Internet. Additionally, other remote sensing projects such as ForNet and TisDat demonstrated how remote sensing data is available for land use management decisions. Internet outreach programs exhibits included a resource for classrooms wanting to connect with NASA scientists and engineers via the Internet, and Telescopes in Education, a program through which students can make observations at the Mt. Wilson Observatory, California, via modem. Aeronautics project exhibits included the Lego Data Acquisition and Prototyping System (LDAPS) a project which fosters hands-on learning of engineering concepts by using Lego toys and Plane Math, and an Internet-based "Curriculum on Math and Aeronautics for Children with Physical Disabilities."

The conference was a great success," said William Likens, IITA Program manager. "We were able to demonstrate how newly emerging communication technologies are being used to bring NASA's science and engineering data to schools and the public.

For further information visit:

http://www.aero.hq.nasa.gov/hpcc/reports/96anrpt/iita96/iita96anrpt.html

"At the first conference we talked about our plans. Now we are talking about all of the things we have actually done."—Principal Investigator, Charles Wood.

Outreach Activities

Ames Research Center (ARC)

- The Kindergarten Through Grade 12 (K-12) Internet Initiative held Open House to inform the public of the on-line interactive projects and the Teacher Resource Center services available.
- "NetDay & Beyond", a virtual conference that allowed people from across the globe to participate in on-line, interactive events via the Internet, was held on October 12, 1996.

Information on ARC's Open House provided by Susan Lee. Virtual conference provided by Pat Kaspar, Contributing Editor, ARC.

Goddard Space Flight Center (GSFC)

- GSFC hosted the sixth annual NASA Summer School for High Performance Computational Physics in July. Sixteen Ph.D. candidates in Earth and space science disciplines received instruction in computational physics and hands-on lab experience in programming the Cray T3D.
- K-12 Project manager, Mark Leon, ARC, approved GSFC's FY97 High Performance Computing and Communications Information Infrastructure Technology and Applications K-12 proposal. The $151K proposal complements Maryland Governor, Parris Glendening's, initiative to wire all Maryland schools for Internet connectivity. The proposal includes developing Internet-based K-12 activities as follow-on to the Maryland Ambassador Program. The proposal also includes support fort the Stevens Institute Hispanic Distance Mentoring Program.
- Minority University-SPace Interdisciplinary Network (MU-SPIN) Project and Deputy Project Managers, Jerome Bennett and James Harrington, presented the annual report on the seven Network Regional Training Sites to NASA Headquarters. The project obtained approval, with some overguide, of MU-SPIN's recommended funding increase.
- Marilyn Mack coordinated the 1996 Visiting Student Enrichment Program (VSEP). A record 27 students participated in science projects with GSFC mentors from the Earth and Space Data computing Division, the Laboratory for Atmospheres, the Space Science Data Operations Office, the Flight Dynamics Division, and the Data Systems Technology Division. Scientific Communications Technology Branch-mentored VSEP students from the University of Iowa, Goshen College (Indiana), University of Pittsburgh at Johnstown, and Reno High School (Nevada). Visit the VSEP homepage at:

  http://sdcd.gsfc.nasa.gov/VSEP96/vsephtml_corr2/VSEP.html

- The Global Learning and Observations to Benefit the Environment (GLOBE) interface <http://globe.gsfc.nasa.gov> received a Federal Showcase Award at the National Science Foundation/NCSA Federal Webmasters Workshop '96. Preparation for GLOBE's privatization is underway as the Scientific Visualization Studio (SVS) develops training exercises on the operation of GLOBE's new visualization server. Began "GLOBE on Demand", an effort to extend the server to visualize the entire GLOBE archive using commercial, multiplatform visualization/analysis software packages. The SVS created sample WWW GLOBE pages in United Nations international languages including French, Spanish, Russian, Chinese, and Arabic.

Information provided by Judy Laue, Contributing Editor, GSFC.

Jet Propulsion Laboratory (JPL)

- JPL's Stardust project, in conjunction with the Challenger Center for Space Science Education and the JASON Project, is bringing the magic of comets into thousands of classrooms across America this school year.
- JPL hosted its annual Open House on June

8-9, offering various interactive activities, laboratory and test demonstrations, multimedia presentations, and exhibits encompassing an entire range of endeavors in chemistry, communications, computing, electronics, mechanical and thermal design, microdevices, robotics and automation, space science, and spacecraft instrumentation and design.

- The lab hosted four students each from Cal State Los Angeles, North Carolina A&T State University, and the University of Texas at El Paso in the collaborative effort between JPL and the three universities to mentor students in the Minority University System Engineering program. The students spent nine weeks on lab to create a prototype satellite, working with faculty advisors and JPL engineers.
- Mission to Planet Earth hosted an educator's workshop entitled "Earth's Oceans and Atmospheres Educators Conference" in October, sponsored by JPL's Education Affairs Office, NSCAT, TOPEX, and AIRS. Earlier—in August— the NSCAT Launch and Educators Workshop was held, with approximately 200 participants in attendance.

Information excerpted from NASA press releases, the JPL Universe, and from the Public Affairs Office.

General

- NASA recently announced the winners of the Experimental Program to Stimulate Competitive Research (EPSCoR): South Carolina, Kansas, Oklahoma, and Nebraska. Each will receive a three year, $500,000 annual award to enable them to develop Earth science, space science and applications, aeronautical and space research, and technology programs. EPSCoR's goals are to contribute to a stronger science and technology base, broaden geographic participation of technologically sophisticated businesses and industries while supporting a more competitive national economy, strengthen science education and expand science and engineering training opportunities, particularly for women and minorities, and reinforce the importance of supporting science and technology.
- This past summer NASA implemented "Discover Earth", a new education activity for teachers of grades 5-12 that focuses on Earth system science and the key issues of global climate change. The first of three, annual Discover Earth summer workshops was conducted at the University of Maryland-College Park (UMCP), with session themes of 1) clouds, radiation, water vapor, precipitation, 2) greenhouse gases and atmospheric chemistry, and 3) ozone and stratospheric chemistry. Discover Earth is managed by the Institute for Global Environmental Strategies and conducted in collaboration with the UMCP and the Earth System Science Center at Pennsylvania State University.
- In July 30, teachers from around Alabama participated in the Project EarthSense Teacher Workshop conducted by the Global Hydrology and Climate Center and the Division of Continuing Education of the University of Alabama, Huntsville. Teachers studied techniques used by NASA reseachers to "sense" or measure the physical world around us and studied an variety of space, aerial, and ground-based remote sensing techniques used in climate change research.
- NASA and the University of North Dakota are collaborating to offer a computerized course in telerobotics, the study of the operation and control of a robot at a distance. This class will enable students to attend virtual classrooms on the Internet and to earn college credit. More than 100 students from various countries (England, Australia, Malaysia, Canada) will hear lectures on "Robotic Vision" and "Automating a Dexterous Robotic Arm" during the experimental course. At the end of the course students in the class will be allowed to drive a robot at a distance from their remote sites. Registration information can be accessed at :

  http://www.space.edu

Information excerpted from NASA press releases.

Feature

Global Change Master Directory Releases Version 5

Lola Olsen, Global Change Data Center, Goddard Space Flight Center

The Global Change Master Directory (GCMD) has announced the release of a new version of its directory software, designated as Master Directory 5, or MD5 (the software may be used as a directory for other scientific disciplines, thus the use of the designation MD5). The GCMD has been serving the science community in locating Earth science datasets of interest for several years. The mission of the GCMD is to assist the scientific community in the discovery of and linkage to Earth science data, as well as to provide data holders with a means to advertise their data to the Earth science community.

The GCMD offers dataset descriptions in a standard format, the directory interchange format (DIF). The DIF holds a specific set of information fields in a database to assist in normalizing the search for dataset information. The GCMD philosophy for use of DIF, and thus the specific set of attributes (the metadata), is that the predetermined set of fields is the critical set needed for determining if the datasets returned from a database query are those that define viable alternative datasets for your needs.[1]

The new MD5 is fully configuration controlled and compatible with the Federal Geographic Data Committee (FGDC). MD5 includes 10 new fields and several revised fields. One of the most important new fields is the dataset citation, which provides scientists and researchers with a standard method for crediting a dataset producer. The DIF also now includes temporal and spatial resolutions of the data that help researchers determine if they have identified the appropriate datasets for their research. In addition, the system now offers new parameter keyword valids, plus new and revised source, sensor, campaign/projects, and data center valids, as well as two search options for the Version 5 DIF: MD5-Oracle and MD5-Isite.

1 Definition of Metadata: “Descriptive information that characterizes a set of quantitative and/or qualitative measurements and distinguishes that set from other similar measurement sets.” - Lola Olsen

The search and retrieval option, MD5-Oracle, is based directly on the Oracle database. The package contains a server, two clients (Classic Client and Web Client), and the complete internal operations functions. A completely refurbished operations segment offers greatly improved capability to generate usage statistics. MD5-Isite is based on the contents of the Oracle database. However, the contents are extracted from the database as ASCII files and subsequently indexed for searching as fielded or full free-text with the GCMD’s modified version of the Isite software. The Isite software was developed by the Center for Networked Information Discovery and Retrieval. The package contains a server, an indexer, and a gateway.

Both MD5-Oracle and MD5-Isite will be also installed at the European Space Agency and Japan’s National Space Development Agency Coordinating Nodes of the Committee on Earth Observing Satellites’ International Directory Network (IDN), as well as at the Canadian Centre for Remote Sensing, Deutsche Forschungsanstalt fur Luft-und Raumfahrt, and Commonwealth Scientific and Industrial Research Organization in Australia Cooperating Nodes. The MD5-Isite will be installed at the Centre National d’Etudes Spatiales in France, the United Nations Environment Programme in Nairobi, the Comision Nacional de Actividades Espaciales (National Commission on Space Activities, Argentina), the Japan Information Center for Science and Technology, and at the Instituto Nacional de Pesquisas Espacias in Brazil. Build and configuration requirements will be available on GCMD’s newly revised Web site and will be distributed to all IDN nodes.

Authoring tools

Several DIF authoring tools for DIF Version 5 have been completed by the GCMD staff. These include:

- DIFmacs - This tool is built on the Emacs text editor on UNIX platforms. DIFmacs is especially useful for those who write many DIFs. <ftp://gcmd.gsfc.nasa.gov/pub/md_install/difmacs.V5.tar.gz>

- DIFweb - an interactive WWW form that allows you to select the fields you wish to complete, enter the information, then send the DIF to themselves or staff <http://gcmd.gsfc.nasa.gov/cgi-bin/mduser_dir/testdifweb)> or <http://gcmd.gsfc.nasa.gov/cgi-bin/difweb>
- DIFwrite - a simple PC DOS based tool that is useful for authors without internet access <ftp://gcmd.gsfc.nasa.gov/pub/DIFwrite/difwri_5.zip>

Other tools available include DIFent (from the Commission of the European Communities) and the United Nation's Environmental Program's Housekeeping Tool. All of the above tools include the new fields, valids, and format. The GCMD staff has completed the work needed to load, extract and display Version 5 DIFs from the database. All Version 4 DIFs currently held by the GCMD have been updated and reloaded in the new Version 5 format by the GCMD staff.

For further information on the new fields, format, and valids access:

http://gcmd.gsfc.nasa.gov/difguide/difman.html

**Note: Perl scripts are available to assist in converting Version 4 DIFs to Version 5 DIFs. You may obtain this conversion package from the American Coordinating Node (GCMD) anonymous ftp site:*

ftp gcmd.gsfc.nasa.gov
login: anonymous
password: your email address
cd pub/conversion_scripts/difV4_2_difV5.tar.gz

However, please be aware that all DIFs in the directory have already been converted.

Feature

Creating On-Demand Visualizations

Shahram Shiri and John Cavallo, Hughes STX, Goddard Space Flight Center

The availability of remote sensing data from various government and private organizations has provided the potential for better understanding of global environmental changes. The advent of World Wide Web (WWW) technologies has provided a mechanism for collecting and distributing data over vast geographic regions. Use of these data affords the public a tremendous opportunity to learn about the environment. However, these data are essentially inaccessible without visualization. The Global Learning and Observations to Benefit the Environment (GLOBE) program, an international program initiated in the US, provides visualized data on the World Wide Web (WWW) daily.

GLOBE uses these data to support a world-wide network of students, teachers, and scientists working together to study and understand the global environment. GLOBE students make environmental measurements near their schools and report their data over the Internet. Scientists use GLOBE student data in their research and provide feedback to the students to enrich their science education. Images are created from the student data sets, and from forecast remote sensing data sets, and are then posted on the WWW.

Currently GLOBE produces over 5700 images each day, The data visualization server, based on a Silicon Graphics Inc. Challenge, provides access to over 6300 images for the entire world through a series of WWW pages. Also, the GLOBE networks process nine reference data sets and 14 student data sets.

Image production and generation

Automatic image production and on-demand image generation have been major concerns in the development of the GLOBE visualization system. In an evaluation and assessment of available visualization software packages, IBM/Data Explorer (DX) was selected over other packages for the production of several GLOBE products: automated production of processed images; on-demand, WWW-accessible visual images; automated movie production of data products; and glossy (poster) image generation. For the past year, IBM/DX has been integrated into these several categories of GLOBE development.

Depending on the type of GLOBE product, pre-processing and post-processing of data are performed to enhance the visual products. In addition, DX2VRML module in DX is used to produce global models of environmental datasets and port them as virtual reality modeling language geometry for use with virtual reality systems. For production of images, remote sensing reference data and student measurements are preprocessed and imported to a series of IBM/DX networks that produce a variety of cartographically projected images. The DX images are then postprocessed for WWW pages by addition of annotations, color bars, and color corrections for Netscape browsers.

Networks

A series of automated DX networks was created, using DX Visual Programming Editor, to cartographically project incoming datasets and generate multiple levels of zoom to global regions. These networks, in a production environment, run as batch jobs where ingest of data and image production run in automated mode.

In a prototype attempt, a series of on-demand DX networks produced higher-level zooms with a variety of data products accessible through WWW pages. These networks can be either activated by filling Forms WWW pages that activate DX networks in script mode or running the DX networks in server mode waiting for an update in the configuration file. Also, JAVA applets could register a location in an image and pass that information to DX networks for zooming to that particular location.

Additionally, a series of networks were generated to produce movies of student data and/or reference data over a period of time. In a series of movies created for Cable News Network (CNN), DX generated the necessary images and Wavefront/Composer was used to compose the final movie segment with titles, color bars, and annotations in script mode. NDVI movies (small and large) show global vegetation index for 12 months of 1991 overlaid on National Oceanic and Atmospheric Administration (NOAA) five minute gridded elevations/bathymetry (ETOPO5) map.

Besides creating movies and on-line images, DX was used to print high-resolution public relations images up to 4000 x 4000 pixels. Again, similar to other categories of GLOBE development, images produced in DX were post-processed with titles and color bars.

Data processing

The GLOBE visualization server provides images of environmental data worldwide, some of which are student measurements while others are reference data from the National Weather Service (NWS) or from satellites in Earth orbit. The NWS reference data, produced in GRIB format, are converted into hierarchal data format (HDF) and imported into the DX networks. In addition, the text file list of student reporting stations is preprocessed in tabular format readable by general importer of DX. Other reference data such as advanced very high resolution radiometer (AVHRR) normalized difference vegetation index (NDVI) are processed in 8-Kilometer resolution and then converted to HDF format.

The post-processing step adds color scale, explanatory text, and icons to make the image more visually interesting and informative. The color scale shows the relationship between color and value. The text provides the location of the view, the date of the data, the dataset name, and a brief description. The icons represent the GLOBE program and the data set shown. The color scales are pre-generated using a DX network that directly uses the color table of each visualization. Postscript is used to generate the values on the scale, outlines, and tick marks. The icons are supplied by the WWW page designer.

At run time, Perl scripts are used to control the creation of auxiliary image files and to composite the elements into a GIF image for the WWW. An image of the explanatory text is generated at run time for each visualization by the Perl script creating postscript commands that are then rendered to a file. Using postscript provides accurate control over the font and the location of the text, giving a finished look to the image. The Perl scripts also control NetPBM programs that place the elements on the image.

Conclusion

For the past year, IBM/DX was integrated into several categories of GLOBE development. The major concerns in the GLOBE visualization system have been automatic image production and on-demand image generation. DX provides the flexibility of allowing networks to be created interactively with Visual Programming Editor and allowing to run them in batch mode in a production environment. For on-demand applications, the automated DX networks were modified to read configuration files created from CGI scripts. The configuration files depict the location and the amount of zoom desired for each image requested.

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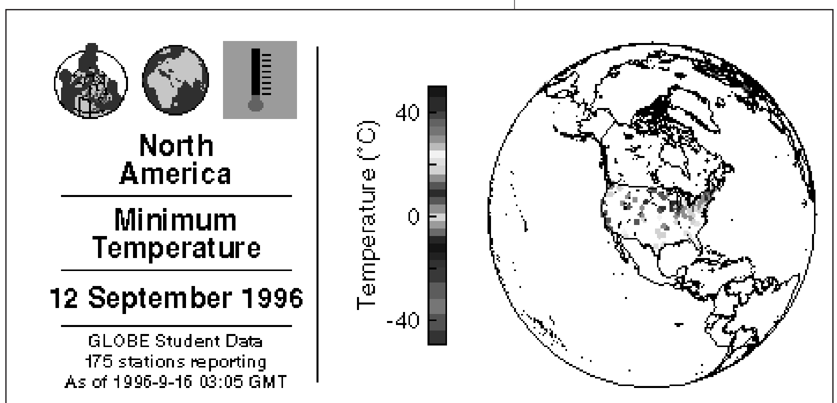
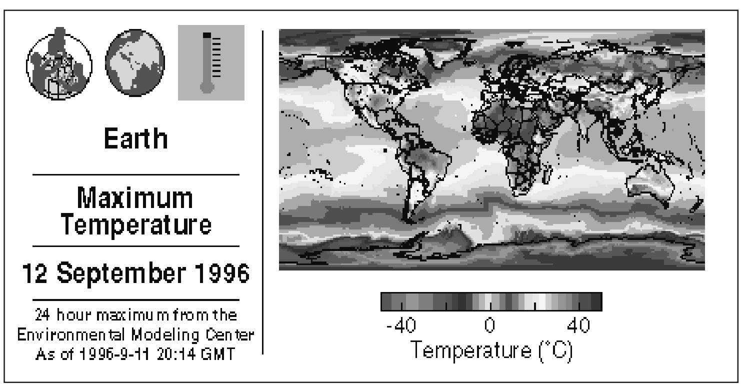
Acknowledgments

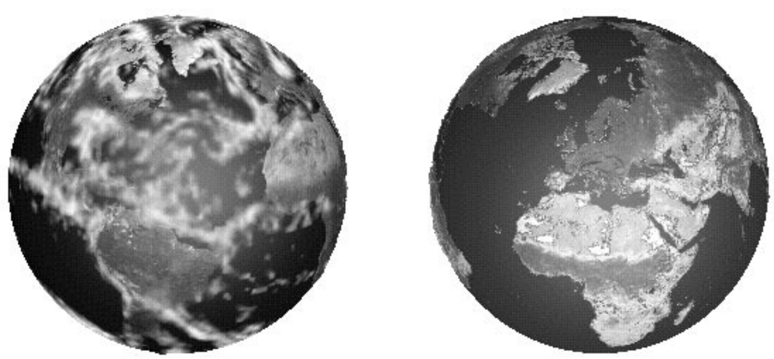
Support for this work was provided by the GSFC's Scientific Visualization Studio, Horace Mitchell, head, and Richard White (GSFC) in collaboration with GSFC's Mesoscale Atmospheric Processes Branch, Fritz Hassler, head. We wish to extend special thanks to Lloyd Treinish, IBM Data Explorer group (IBM), for assisting every step of the way by providing example DX networks and program debugging. In addition, we would like to thank Ray Twiddy (Hughes STX), who generated beautiful GLOBE public relations posters and produced numerous movies for CNN; Cindy Starr (Hughes STX) and Judy Laue (Hughes STX) who edited this paper; Jeff de La Beaujardiere (USRA), GLOBE Visualization Server Webmaster; and Chris O'Handely (SSAI) who assisted with making the pictures available on the WWW and generating color maps for the datasets.



Global student-measured minimum temperature reported at September 12. 1996 (North American continental view)



Global surface maximum temperature over 24 hour period at 1 degree resolution (National Weather Service Aviation Forecast model)



Left image shows forecast cloud cover from NWS/AVN dataset. Right image shows NDVI vegetation index.

Acomplishments

Information Systems Program Highlights

Major accomplishments achieved by NASA's Information Systems are highlighted below. They cover work performed from August through November, 1996, and reflect the combined efforts of many people.

Ames Research Center (ARC)

NASA Internet—Christine Falsetti

- Prepared a report on network security for the Earth Observing System (EOS) committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services Network Subgroup meeting held in September. NI also prepared a draft *CEOS Acceptable Use Policy* and a draft *CEOnet Security Policy.*

- Supported the development of Global Observation Information Network demonstrations to be held after the G-7 summit meetings in Boulder, CO, in June, 1997. "G-7" refers to the world's seven industrial giants—the US, France, Canada, Italy, Germany, Japan, and Great Britain. NI is coordinating the development of the presentations's structure, demonstrations, and network connectivity.

- Coordinated exchanges of information among the G-7 Environment and Natural Resources Management, the US Global Change Data and Information System Program, and CEOS International Directory Network on a common thesaurus of key words for global change data and information.

- Conducted various collaborative videoconferencing testbeds, in conjunction with GSFC's EOS prototyping groups, to demonstrate and evaluate the use of both unicast and multicast videoconferencing technology for scientific team collaboration. Testbeds have successfully used multicasting backbone and Communique Software. Further testing will include videoconferencing with an asynchronous transfer mode interface card.

Information provided by Pat Kaspar, Contributing Editor, ARC.

Goddard Space Flight Center (GSFC)

Scientific Computing Branch—Nancy Palm
NASA Center for Computational Sciences (NCCS)

- Installed three Cray J932 systems. The charney and the suomi systems are available to the entire NCCS user community, and the mintz system continues to be dedicated to the Data Assimilation Office. The current configuration of the J932's follows:

System	charney	suomi	mintz
CPUs	20	24	24
Memory	4 GB	8 GB	4 GB
Disk Capacity	216 GB	144 GB	216 GB
Peak GFLOPS	4 GFLOPS	4.8 GFLOPS	4.8 GFLOPS
Networking	Ethernet	Ethernet	Ethernet
	FDDI	FDDI	FDDI
	HiPPI	HiPPI	HiPPI
	ATM (OC-3)		

In 1997, the J932's will gain 28 CPU's, for a total of 96 CPU's. The final configuration will represent a tripling of computer power with a sixfold increase in disk and an eightfold increase in memory when compared to the former NCCS workhorse—a Cray C98/6256.

- Upgraded the Convex/UniTree system with an IBM 3494 robotic tape subsystem and eight 3590 IBM "Magstar" tape drives. This new robotic mass storage technology, being prepared for integration with the Convex/UniTree mass storage system, will add over 24 TB of uncompressed capacity to the Convex/UniTree system, bringing the system to 48.8 TB of on-line storage capacity.

- Installed an interim IBM/MVS ES9121-210 in the NCCS to support the IBM/MVS user community from June through September 30, 1996. At the end of that period, the equipment was deinstalled, no longer supporting the IBM/MVS community, in accordance with the consolidation of administrative computing and in collaboration with the NASA Automated Data Processing Consolidation Center at Marshall Space Flight Center.

High Performance Computing and Communications (HPCC)

- NASA Headquarters announced the Earth and Space Science (ESS) Cooperative Agreement Notice awardees (expanded press release at:

  http://sdcd.gsfc.nasa.gov/ESS/news.can.html

- Signed a Cooperative Agreement with Cray Research Inc, a wholly-owned subsidiary of Silicon Graphics Inc, to place a T3D system at GSFC in July 1996, and upgrade it to a T3E by June 1997. All payments will be made based on completion of milestones, which involves support of the Round-2 Grand Challenge Investigator teams and the broader Earth and space science community.

Scientific Communications Technology Branch—Mike Hollis, Acting

- Obtained improved Asynchronous Transfer Mode (ATM)—based throughput performance over the Advanced Communications Technology Satellite (ACTS) between GSFC's Cray J932 and JPL's Cray Y-MP/T3D, with transfers exceeding 57 Mbps compared to 36 Mbps from previous ACTS test. Achieved highs of over 82 Mbps over terrestrial-based National Research and Education Network (NREN) compared to 66 Mbps achieved in previous NREN tests.

- Provided or supported several live demonstrations that showcased the 155-Mbps ACTS/terrestrial network interconnections at GSFC including the following:

  -A real-time demo of a virtual Global Legal Information Network at the Advances in Digital Libraries '96 Conference at the Library of Congress (LoC) with assistance from the LoC, the National Library of Medicine, the University of Maryland-College Park, and Lewis Research Center (LeRC), May 13

  -Live demos of Mayo Clinic telemedicine applications at the Armed Forces Communications and Electronics Association's 50th International Conference/Exposition held in Washington, D.C., June 4-6

  -Live demos of GSFC/LeRC-developed virtual reality extensions to the 3D TerraVision image browser at the 1996 International Conference on Communications (SuperComm/ICC96) Conference in Dallas, Texas, June 25-27

Applied Information Sciences Branch—William Campbell

- Installed direct readout ground station equipment for Regional Data Centers at Clemson University, University of Southwest Louisiana (USWL), and University of Maryland, Baltimore County. The RDC project presented capabilities of the RDC system being installed at USWL to 12 Louisiana industrial leaders and USWL administrators. The meeting resulted in a joint-business venture in Louisiana to develop highly accurate weather products covering the Gulf of Mexico.

- The Virtual Environment Laboratory received a Crystal River Engineering Acoustetron II sound generator that represents data aurally. Used with existing virtual environment tools, this equipment could provide a more thorough and efficient means of understanding complex data. Scientists interested in exploring their data with virtual reality should contact Steve Maher, Applied Information Science Branch, at:

  301-286-3368.

- Pat Gary and Steve Maher gave a demo to the Advanced Technology Demonstration Network Steering Committee on upgraded high performance ATM network routes between GSFC and EROS Data Center (EDC). One-meter resolution datasets of Yosemite Valley from a combination of aircraft and SPOT satellite imagery stored at EDC were viewed from GSFC in real-time. GSFC virtual reality on the 3D terraVision image browser was used.

Information provided by Judy Laue, Contributing Editor, GSFC.

Jet Propulsion Laboratory (JPL)

Planetary Data System (PDS)—Sue McMahon

- PDS has a new web address:

  http://pds.jpl.nasa.gov

- Implemented new PDS Atmospheres Node, led by Reta Beebe, at New Mexico State University. All data from the previous node team has been transfered to the new node, with additional sets added to the collection and available online. Science expertise has been organized across six areas, with data curation and node leadership at NMSU:

NMSU	Reta Beebe	Gas Giants
GISS/GSFC	Anthony Del Genio, Larry Travis	Venu
ARC	Bob Haberle, Jim Murphy	Mars
GSFC	John Pearl	Infrared
Stanford	Len Tyler/ Richard Simpson	Occultation
(future subnode)		Ultraviolet

- Added new data sets to the PDS-published planetary collection in FY96 from these projects: Clementine, Pioneer Venus Orbiter, Magellan,Voyager, Viking Lander and Orbiter, Pioneer 10 and Pioneer 11. These sets were restored by PDS nodes to PDS standards, using mission data and science peer reviews to assure quality products. Additions for FY96 include 228 CD-ROMs and 724 CD-write onces; many of these sets are also available on-line via the PDS web pages.

- Began archiving Shoemaker-Levy 9 data from spacecraft and ground-based sources (Small Bodies Node), and Saturn Ring Plane Crossing data sets (Rings Node).

- Worked closely with the following missions to help draft their archiving plans: NEAR, Cassini, Lunar Prospector, Mars Global Surveyor, and Mars ’96.

- Completed PDS Educational CD version 1.5, *Welcome to the Planets* ™. Thousands of copies have been distributed. This version includes a curriculum guide for educators, sponsored by the NASA HQ education division, and is available to educators through NASA’s Central Operation of Resources for Educators (CORE) as well as via NSSDC.

- Completed Version 1.0 of NASAVIEW, a PDS object display tool, for Sun OS. This tool provides simple display capability for image data. PDS plans to support the tool across many platforms. More features are planned for FY97.

- Completed Object Access Library version 1.0. Object Access is a set of library routines, written in C, which can be used to develop software applications that access PDS data objects.

Information provided by Sue McMahon, PDS.

Feature

Planetary Images Available On the Internet

Myche McAuley and Elizabeth Duxbury, Planetary Applications Group, Jet Propulsion Laboratory

The Imaging Node of NASA's Planetary Data System (PDS), in cooperation with the Solar System Visualization Project and Jet Propulsion Laboratory's (JPL) Public Information Office, has developed a World Wide Web (WWW)-based image browser, called the Planetary Photojournal. This browser, aimed at a broad user community (everyone from school children to science publishers and researchers), is designed to provide easy access to high quality, processed planetary images that have been press-released by NASA and other institutions. You can browse images, read the associated captions, and download the image data in a number of different formats. Hot links are also provided to allow you to access companies from which hardcopy products can be ordered.

As active flight missions acquire new images of the planets in our solar system, the images are made available through the Photojournal at the same time they are released to the press. The Photojournal database is also being backfilled with data from older missions. Currently, over 400 images are available.

Using the Photojournal

The Photojournal's first page provides a mosaic of the planets in our solar system (Figure 1). A simple "point-and-click" of the mouse on this image selects a planet of interest, such as the Earth. The "Planet Page" for the selected planet is then displayed—a page that provides links to other sites on the Web with further information. There are also menus for refining your search: a target-based menu and a spacecraft-based menu. The target-based menu includes the planet selected and all accompanying satellites for which the Photojournal has images. Thus, in this example, you may choose between the Earth and the Moon. The query-based menu permits you to 1) request the images of your planet selection acquired from a specific spacecraft or instrument (i.e. Clementine or Galileo) or 2) request images from all missions to the planet selected. When your selections have been made, you may initiate a search of the Photojournal database by clicking on the "Submit Query" button. A listing of all images in the Photojournal matching the input query is then displayed. A thumbnail image is provided for each picture listed, as well as the image title. Listing the image title allows users who are limited to text-based web browsers to peruse the Photojournal and download data from it. Simply clicking on one of the thumbnail displays the next page—the "Catalog Page" (Figure 2).

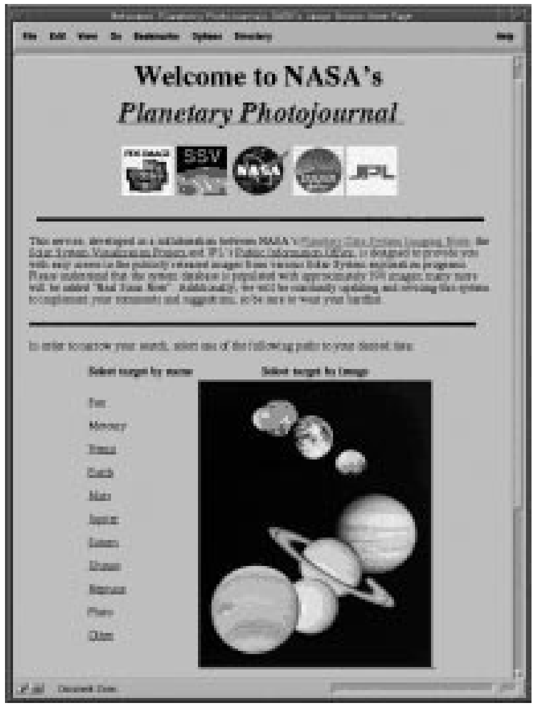
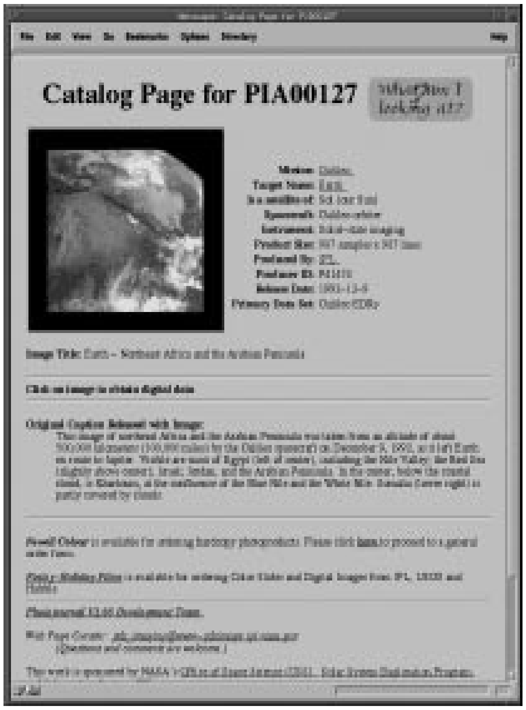


Figure 1. Photojournal homepage—mosaic of the planets in our solar system

The Catalog Page provides a"browse" size version of the image (256 pixels in height), along with textual information (including the original press-release caption) describing the image. There is also supplemental information, including links to more information about the mission and the associated planet, the name of the image producer, and the source data name from which the image was derived. At the bottom of this page, you will find links to professional photo labs, from which hardcopy prints and slides of the image can be ordered. Clicking on the browse image displays the "Digital Download Page", from which you can select an output format, and download a digital version of the full sized image over the Internet.

As active flight missions acquire new images of the planets in our solar system, the images are made available through the Photojournal at the same time they are released to the press.

Figure 2. Photojournal's Catalog Page



Behind the scenes

The Photojournal, being a collaborative effort, is currently split between two geographically separated websites. From the beginning, the system was designed to be "transparent" to the user. The goal is to have completely independent sites, able to simply query each other. However, it became evident that a more efficient solution is for each site to contain its own copy of the database and simply point to images that did not reside locally. In this way, whenever you select an image that does not reside locally, you are invisibly pointed to the image at the other site. This is possible because the majority of the Photojournal's "pages" do not exist in static form at all. Heavy use of the common gateway interface (CGI) mechanism allows you to experience a consistent look-and-feel, even though the images are spread between these two sites. Indeed, by developing the system in this way, other sites that have image archives of their own can easily be added. The end result is that the image collection can grow as new institutions are added, while providing a consistent interface.

In the future

As with any large collection of data, changes are required from time to time. One request from the science community is to allow for updated (and possibly revised) image caption information. The original captions released with the image are a"snapshot" of the (then) current understanding of the observation. Years later, the science community stated, it should be possible to update and/or revise these captions to encompass new information and knowledge. Also, the captions should be usable by a wide audience of users with differing educational backgrounds. The original caption would always be kept, but would be supplemented with this additional information.

A parallel goal of the PDS Imaging Node is to create interfaces to the underlying science data from which the press release images found in the Photojournal were made. Work is currently underway to allow you to explore this data in an intuitive, interactive fashion. Linking the Photojournal to these systems is com-pelling—you will be able to proceed from the highly processed press release to the actual science data from which it is created. This will help alleviate one large burden that has historically vexed science users; the need to understand the original data's archive architecture and format.

For further information about the Planetary Photojournal access either website, or contact Sue LaVoie at, respectively:

http://photojournal.jpl.nasa.gov/
http://pdsimage.wr.usgs.gov/PIA/
Susan.K.LaVoie@jpl.nasa.gov

A sample of images available in the Photojournal.